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A STRUCTURAL FLIGHT LOADS RECORDING PROGRAM ON CIVIL TRANSPORT HELICOPTERS

Technical Report

FEDERAL AVIATION AGENCY ★ UNITED STATES OF AMERICA ★

JULY 1966

By

Cyril G. Peckham

F. Joseph Giessler

Joseph F. Braun

Technology Incorporated

Dayton, Ohio

Under Contract FA-WA-4590

For

FEDERAL AVIATION AGENCY

AIRCRAFT DEVELOPMENT SERVICE

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SUMMARY

A flight loads program on a transport helicopter was conducted using a Boeing-Vertol 107-II helicopter operated by New York Airways. The following parameters were measured: airspeed, altitude, vertical load factor, pitch rate, rotor rpm, and two engine torques. Calculations based on the measured parameters included the running gross weight and rate of climb. The data were grouped into mission segments of takeoff and ascent, cruise, descent, flare and landing, and hover. After the best method of data presentation was determined, the data were sorted by parameter ranges. The primary presentation is in the form of bivariate and trivariate tables showing the time spent in each data range. Some of the more significant data effects are presented as histograms. The vertical load factor and pitch rate data are presented as exceedance and probability curves.

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SECTION I

INTRODUCTION

The need for structural loads data from commercial transport helicopters has long been recognized. However, flight test programs to acquire such data have been practically nonexistent. To determine the requirements for such a program, the Federal Aviation Agency sponsored this study, in effect, a pilot program.

The purpose of this program is threefold: (1) to select parameters describing the loads incurred by the structure of the craft and to determine through study of the helicopter performance the adequacy and pertinence of these parameters; (2) to design, install, operate, and maintain a recording system to record the parameters selected; and (3) to acquire, process, present, and analyze the data to determine the optimum means of treating each of these functions in the performance of a full-scale structural loads program.

The test vehicle selected for the program is a Boeing Vertol 107-II helicopter operated by New York Airways in the New York City area. This helicopter carries passengers on scheduled flights between Kennedy International Airport, Newark Airport, and Wall Street Heliport, New York City.

SECTION II

DISCUSSION

A. Data Recording

1. Helicopter Description. Operational data of a helicopter were acquired during the normal transport service of a Boeing-Vertol 107-II helicopter. Under a subcontractual agreement, New York Airways made one of its helicopters, identified by serial number N6675D, available for the instrumentation system.

The Vertol 107-II is a twin-turbine powered, tandem rotor helicopter with an all-metal fuselage of semimonocoque, stressed-skin construction. The power plant is located in the base of the fuselage aft pylon and consists of two General Electric CT 58-110-1 engines. Engine operation is electrically controlled from the cockpit. The aft transmission, also located in the aft pylon, drives two AC generators which supply the primary electrical power.

The rotor system consists of two 3-bladed, fully articulated, partially overlapped rotors which are synchronized by a mix box, forward and aft transmissions, and interconnecting drive shafts.

An electronic stability augmentation system (SAS) is integrated with the flight control system to provide a high order of stability during all modes of flight. A speed trim system, also integrated with the flight control system, maintains the proper longitudinal trim of the helicopter automatically at forward speeds above approximately 40 knots.

2. Data Acquisition System. The data acquisition system consists of an oscillograph recorder, a bridge balance and signal-conditioning unit, and data signal sensors. The oscillograph recorder, the "heart" of the system, was selected as the recording device because of its simplicity and its ready adaptability to semiautomatic data processing techniques and equipment previously employed on similar efforts by Technology Incorporated.

The bridge balance and signal-conditioning unit, the medium to transform the sensor signals into voltages compatible with the recorder, was designed so that it would be sufficiently versatile in performing the calibration nulling of the strain gage bridges, filtering, and signal conditioning functions.

The sensors or transducers needed to measure the parameters which describe the loads incurred by the aircraft and the environmental conditions

accompanying the loads, were selected on the best basis of input/output values, performance, and environmental specifications.

Besides all pertinent drawings, the appendix presents a detailed description of the data acquisition system.

3. Parameters Measured. The parameters recorded were airspeed, altitude, normal acceleration at the helicopter's center of gravity, pitch rate, engine torque (both engines), and rotor rpm. These variables represent the significant motions as well as the overall performance of the helicopter.

The normal acceleration at the center of gravity, the pitch rate, and the combination of airspeed and altitude can be used to determine the forces acting on the craft. These parameters are also good indicators of the severity of the flight loads incurred during the several mission segments. The rate of ascent or descent, as observed in the altitude recording, also aids in defining loads severity.

The engine torque and rotor rpm are useful in evaluating the performance of the craft. The calculated tip speed ratio, μ, the ratio of the forward velocity component in the plane of the rotor to the tangential velocity at the tip of the rotor, is also useful in evaluating helicopter performance and in describing the operating envelope of the craft.

The helicopter gross weight and the air temperature were manually recorded prior to each takeoff.

Supplemental data included items such as cargo; date; passenger weights; and barometric pressure, fuel and air base at takeoff and landing.

B. Data Processing and Analysis

1. Data Editing. Data processing editors first checked all oscillograms for evidence of any instrumentation malfunctioning. All faulty records were removed from processing and a report was made to the Instrumentation Section. Then the editors timed all acceptable records and demarcated the following mission segments in each flight.

(1) Takeoff and Ascent (Mission Segment 1): Includes takeoff and climb to steady flight and all ascents during the flight.

(2) Cruise (Mission Segment 2): Includes those portions characterized by steady airspeed and rate-of-climb generally within $\pm$ 800 feet per minute.

(3) Descent (Mission Segment 3): Includes all descents during the flight, as identified by decreasing altitude, decreasing airspeed, and generally decreasing torque.

(4) Flare and Landing (Mission Segment 4): Includes the landing portion of flight beginning with a sharp increase in engine torque following descent prior to landing.

(5) Hover (Mission Segment 5): Includes all portions of flight when the airspeed is below 40 knots.

Also the editors marked the load factor and pitch rate peaks to be read. Peaks so marked were those outside the following prescribed thresholds: 0.8 to 1.2 g for the load factor peaks and -2.0 to + 2.0 degrees per second for the pitch rate peaks. To ensure the inclusion of all peaks in the data processing, the reading thresholds were placed closer to the load factor and pitch rate normals, that is, 1.0 g and 0 degrees per second. Any peaks read inside the prescribed threshold were eliminated during computer processing. The altitude and airspeed traces were so marked for reading that straight-line segments joining the points would reproduce the general pattern of the traces.

Early examination of the data revealed that the pitch rate trace always deflected before a load factor peak during the cruise mission segment. Consequently, the editors marked only the load factor peaks in this mission segment. Then when measuring these peaks, the data readers also measured the nearest preceding pitch rate peak deflecting in the same direction. In all other mission segments, however, the load factor and the pitch rate peaks were marked independently of each other.

2. Data Reading. All selected in-flight recordings were read on semi-automatic data readers and the results recorded automatically on IBM cards. The digitized data were checked for format and for accuracy of trace representation. A quality control check included precise manual measurements to verify the reading accuracy. The differences between the machine and manual readings were used to calculate the mean and the standard deviations. Table I shows the mean deviation and the 99.7% confidence limits for each of the parameters.

3. Data Processing. The acceptable data were processed through an IBM 7094 computer. Values for each parameter were grouped in pre-selected ranges. Whenever an airspeed range or altitude range was skipped in the time history, the computer interpolated a value and made a note of the interpolation. Values outside normal operating ranges were also noted for subsequent checking.

Table I

Quality Control Values for Each Parameter

Parameter	Mean Deviation	99.7% Confidence Limits
Airspeed (at 120 knots)	0.03 knot	± 0.9 knot
Altitude (at 1000 feet)	1.5 ft	± 54 ft
n_z	.002 g	± .03 g
Pitch rate	0 01 deg/sec	± 0.27 deg/sec
Engine torque I	0.03%	± 0.72%
Engine torque II	0.035%	± 0.81%
Rotor rpm	0.09 rpm	± 3.3 rpm

All the significantly high or low values of each of the parameters and all the computer comments were checked against the corresponding oscillograms. This correlation served as a further check of the data reading and the computer operation.

The computer program also included calculating the tip speed ratio μ as follows:

$$\mu = \frac{V}{\Omega R}$$

where

V = airspeed

Ω = rotor angular velocity

R = rotor radius, 25 feet

Since rotor rpm was measured, the equation can be given as

$$\mu = 0.6448 \frac{V}{rpm}$$

with airspeed given in knots.

C. Data Analysis

1. Data Presentation. The data are presented in both tubular and graphic form. The tables were arranged so that all measured and calculated data pertinent to a structural flight loads study would be readily apparent. Both bivariate and trivariate tables were used to show the time spent within given combinations of parameter ranges, commonly termed "data blocks." Tables indicating the number of peaks reaching or exceeding given values within certain time units are presented for the vertical load factor and the pitch rate peaks. The times listed in the tables were rounded off to the nearest tenth of a minute. A time value between 0 to 0.05 was printed as "0.0" while a time equal to zero was printed as "0." Parameter range headings indicate only the lower limit of each range.

The graphs consist of histograms, and exceedance and probability curves. The histograms show the percentage of time spent in the various parameter ranges. The airspeed, gross weight, and rotor rpm are also presented as percentages of maximum values as obtained from the pilot's handbook. The exceedance and probability curves present the vertical load factor and pitch rate data. These curves serve directly to predict aircraft life expectancy and to establish design criteria. The data in the various graphs were grouped by mission segment to indicate the relative operational severity imposed by the different flight conditions.

2. Data Analysis. Figure 1 shows for each mission segment the percentage of flight time spent in airspeed ranges. Apparently, the takeoff and ascent time is rather uniform in the lower airspeed ranges and the climb speed is in the 60- to 120-knot range. That the normal cruise airspeed was between 120 and 140 knots is evidenced by the cruise segment showing most of its time within this range. As noted during the cruise mission segment, the maximum recorded airspeed was 144 knots. Airspeeds over 140 knots were reached only during cruise and descent.

Figure 2 shows percentages of flight time spent in selected altitude ranges. Except for the time expended in performing flare and landing from above 500 feet, which was due in part to practice landings on the Pan American Building, the percentages conform to expectations.

As shown in Figure 3, the percentages of time for the respective gross weight ranges are generally the same for all mission segments except hover. The hover percentage discrepancy indicates that most of the hover maneuvers were performed with either empty helicopters or with light payloads. This was due to most hover occurring during test flights.

Figure 4 gives for each mission segment the percentages of flight time spent in rotor rpm ranges. Although the hover segment expended considerable time in the 264- to 275-rpm range, most of the flight time was spent in the 253- to 264-rpm range. The maximum permissible power-off rotor rpm of 298 rpm, or 113 percent, was never exceeded.

Figure 5 presents for each mission segment the percentages of flight time spent in ranges of engine torque expressed as percentages. Takeoff and ascent is characterized by high torques between 60 and 80 percent. Cruise torques are predominantly between 60 and 70 percent, and hover torques fall mainly between 40 and 60 percent. This is due to most of the hover occurring during test flights when the gross weight was low. While the plots and tables for other parameters was based on 316 flight-hours recorded in 2344 flights, those for the engine torque are based on 248 flight-hours recorded in 1798 flights. The discrepancy was due to malfunctioning of the torque recording during 546 flights. No other parameters were affected.

Figure 6 shows for each mission segment the percentages of flight time spent in rate-of-climb ranges. Takeoff and ascent shows the highest rate-of-climb values; however, most of the time in this figure is below 1200 feet per minute. The small percentages of time in a negative rate of climb during takeoff and ascent reflect the fact that the mission segments are distinguished by the major trends in the parameter traces. Similarly small percentages of time in a positive rate of climb are observed in the descent and the flare and landing segments.

Figure 7 shows the percentages of flight time spent in each mission segment, and Figure 8 shows the average time for flights in each route. The route marked "Other" includes all test flights and ferry flights without passengers.

Figure 9 shows for each mission segment and a composite of the segments the number of normal load factor peaks to be expected during each 1000 hours of flight. The highest recorded load factor is 2.015 which occurred during the cruise mission segment of a test flight. The hover segment had the mildest normal load environment. Figure 10 presents the normal load factor data as the probability of given values being reached or exceeded.

Presenting curves of both positive and negative pitch rate peaks for each of the mission segments except for the cruise mission segment, Figure 11 shows the pitch rate peaks to be expected for each 1000 hours of flight. As evidenced, the positive pitch rate exceedance is more severe than the negative pitch rate exceedance and the hover mission segment has the most severe exceedance values of the positive pitch rate. The largest negative pitch rate

peak was recorded during a takeoff and ascent mission segment. Figure 12 presents probability curves for the pitch rate peaks.

Figure 13, a plot of normal acceleration versus the tip speed ratio, shows the operating envelope of the helicopter. Since airspeed affected the tip speed ratio more than rotor rpm, the high values of μ were generally due to high airspeed rather than to low rotor rpm.

Representative of a typical flight record, Figure 14 depicts the Route 6 flight, Newark to Wall Street, flown on 30 November 1964. This flight took 4.70 minutes, the average of the flights on this route being 5.16 minutes. The flight profile is similar to those of the other flights. After gradually approaching the maximum near the middle of the flight, the altitude drops slowly as the craft begins the descent. Engine torque is very steady during the cruise portion. When the slow descent begins, the torque first falls slightly and then holds steady until the airspeed starts to decrease. Thereafter, the torque falls again until just before the flare and landing. During this flight, 37 normal acceleration peaks were recorded, the maximum giving a 1.24 g. The maximum positive pitch rate was 3.2 degrees per second and the maximum negative pitch rate was -3.5 degrees per second. Of the 40 pitch rate peaks recorded, 6 occurred during cruise.

Figure 15 is a record of a test flight whose takeoff and landing both occurred atop the Pan American Building in New York City. The large fluctuation of the pitch rate immediately after takeoff and before landing was also observed in the records of other flights operating from and to this helicopter base. Of particular interest is the takeoff where the helicopter first pitched positively and then gained altitude without increasing airspeed. After climbing about 100 feet, the craft pitched negatively or forward and then began to gain airspeed and more altitude until it reached the cruise condition. The short period of positive pitch, increasing altitude, and constant airspeed did not occur during normal ground takeoff. During the landing of this flight, the maximum positive pitch rate was 3.9 degrees per second and the maximum negative pitch rate was -6.3 degrees per second. During the takeoff following this flight, the maximum pitch rate values were +4.3 degrees per second and -5.7 degrees per second.

Table II lists the data acquired from the scheduled routes. The listing for Route 7 (Test) includes data from all flights not on a scheduled passenger route.

Tables III and IV give for each mission segment and all segments combined the number of recorded pitch rate peaks and normal load factor peaks, respectively. Table III, however, does not include pitch rate peaks for the cruise mission, as these are shown in Table V.

Based on the observation that each normal load factor peak accompanied a pitch rate peak during the cruise mission segment, Table V gives the number of normal load factor peaks versus the corresponding pitch rate for this segment. As indicated, negative values of Δn_z generally correlate with negative pitch rate peaks.

Tables VI through XI list for each mission segment the flight time spent in ranges of altitude, airspeed, rotor rpm, engine torque, gross weight, and climb rate. The table for engine torque is based on 248 hours of flight data recorded during 1798 flights. The tables for the other parameters are based on 316 hours of flight data recorded during 2344 flights.

Tables XII and XIII give the flight time for combinations of altitude and airspeed ranges, the former having a breakdown by gross weight range. The two highest airspeeds, 144 and 143 knots, occurred in the 16,000-17,000 pound and 17,000-18,000 pound gross weight ranges, respectively.

Tables XIV through XVII list, for combinations of engine torque percentage and rotor rpm ranges, the flight time in ranges of temperature, altitude, airspeed, and mission segment, respectively.

Tables XVIII and XIX give the flight time for combinations of altitude and tip speed ratio ranges, the former having a breakdown by gross weight range.

Tables XX and XXI and XXIV through XXVI list the number of incremental load factor peaks for the respective ranges of tip speed ratio. Table XX has a breakdown by mission segment, Table XXIV by engine torque percentage ranges, Table XXV by gross weight ranges and altitude ranges, and Table XXVI by altitude ranges. As indicated in these tables, the cross correlations between the load factor and the other variables are useful in developing load spectrums and profiles for fatigue life prediction. Tables XXII and XXIII present the number of incremental load factor peaks for airspeed ranges, the former having a breakdown by mission segment.

Tables XXVII and XXVIII give the number of pitch rate peaks for the respective ranges of tip speed ratio, the former also having a breakdown by mission segment.

SECTION III

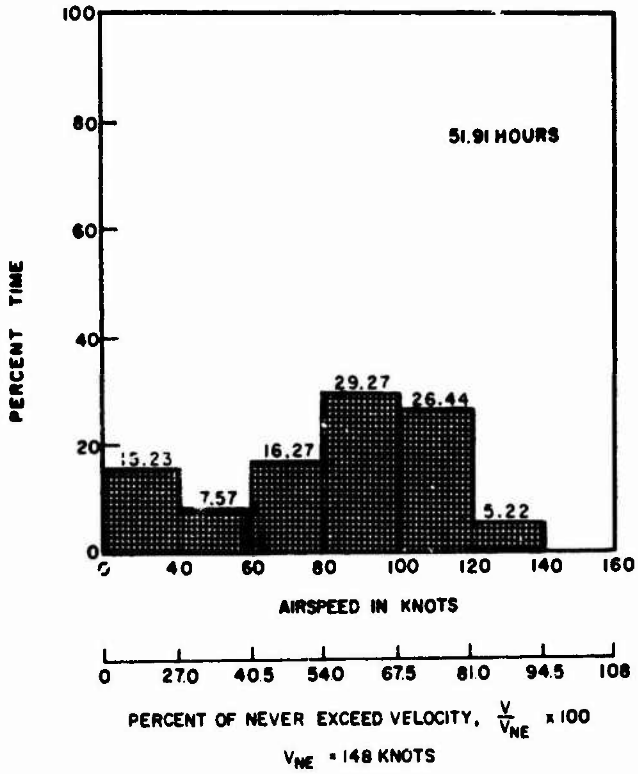
CONCLUSIONS

(1) The trial investigation of the flight loads incurred by the Vertol 107-II helicopter operated by New York City Airways proved the feasibility of a large-scale flight loads program for this type of helicopter used in civil transport. Also each of the parameters chosen for in-flight recording—airspeed, altitude, normal acceleration at the helicopter's center of gravity, pitch rate, rotor rpm, and engine torque—proved meaningful in depicting and interpreting the flight loads. Except for the outside air temperature which should be recorded automatically, other variables supplemental to the above parameters, such as takeoff and landing weight, should still be recorded manually in a large-scale program.

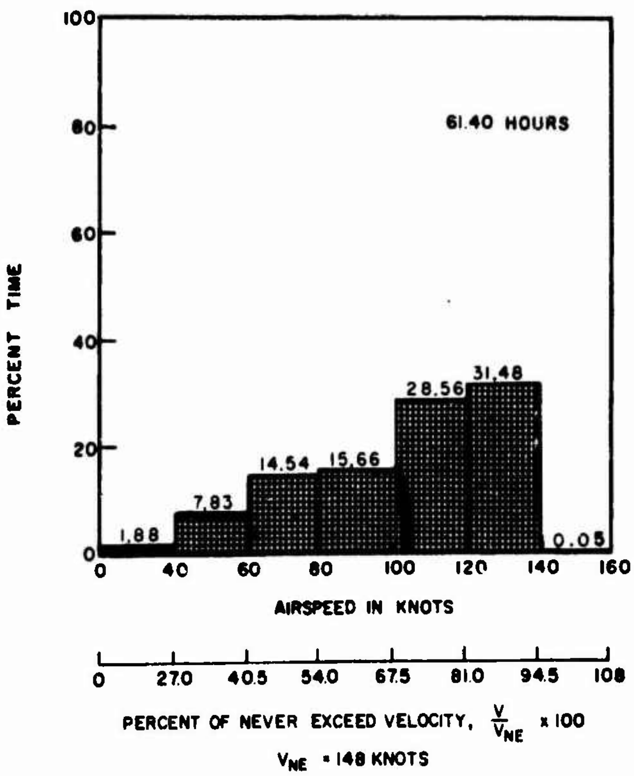
(2) The five mission segments selected for data separation—takeoff and ascent, cruise, descent, flare and landing, and hover—proved satisfactory in studying the distinctive phases of flight.

(3) During the cruise mission segment, a normal load factor peak was always preceded by a pitch rate peak. This relationship existed in this mission segment only.

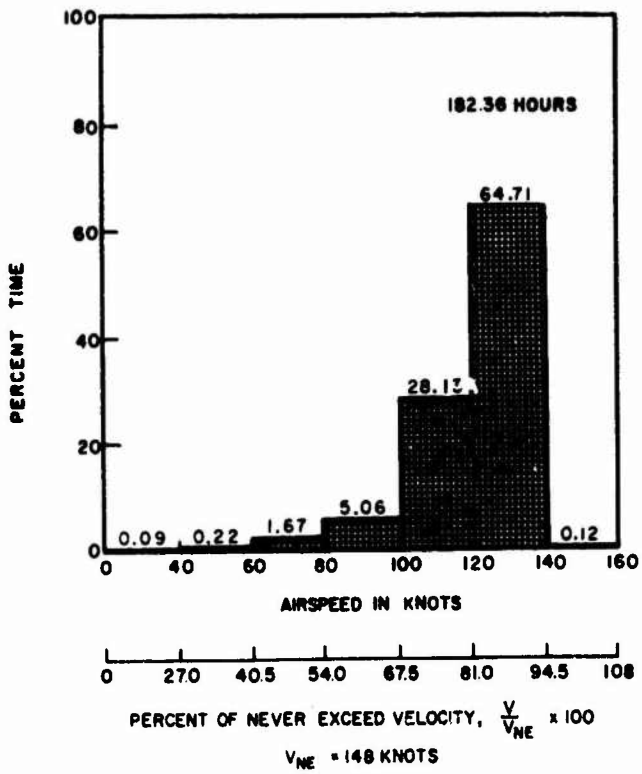
(4) In normal operation, the test helicopter spent more than half of its flight time in the cruise condition with altitude generally below 1000 feet. Also it expended minimum time in performing the takeoff and landing maneuvers.



Mission Segment Takeoff and Ascent

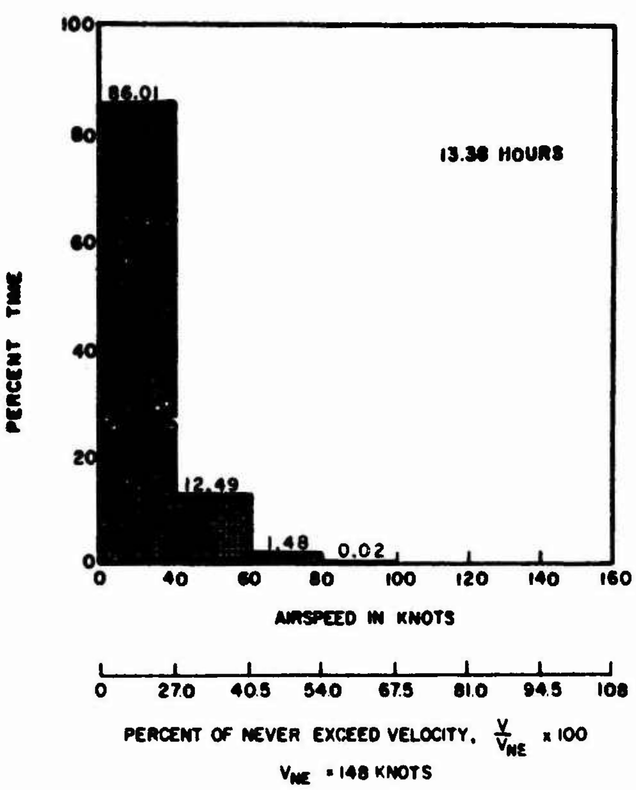


Mission Segment Descent

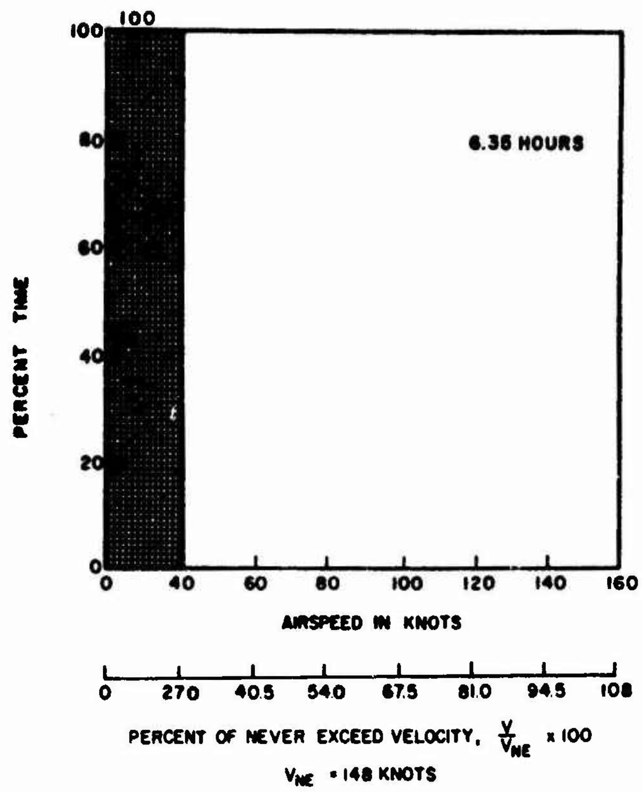


Mission Segment Cruise

Figure 1 Percentages of Flight Time Spent at Airspeed Ranges

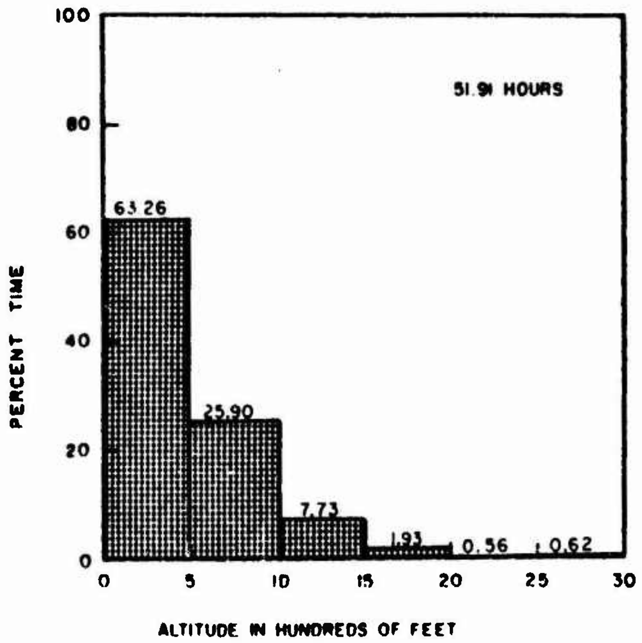


Mission Segment Flare and Landing

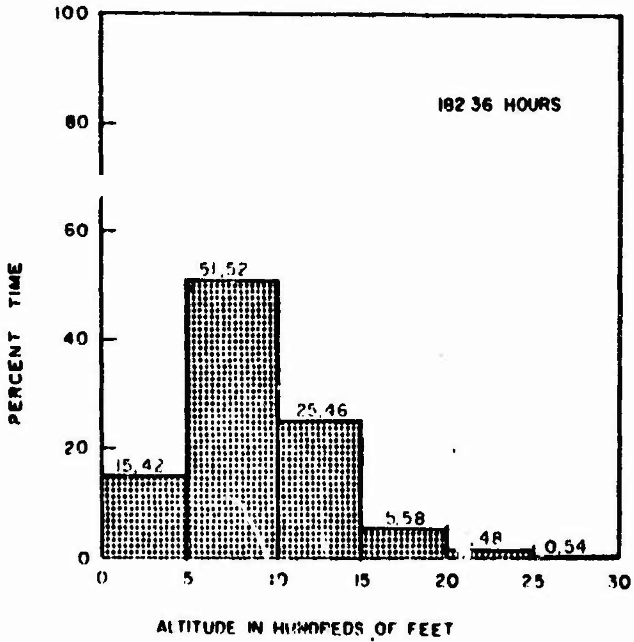


Mission Segment Hover

Figure 1 (cont'd.)

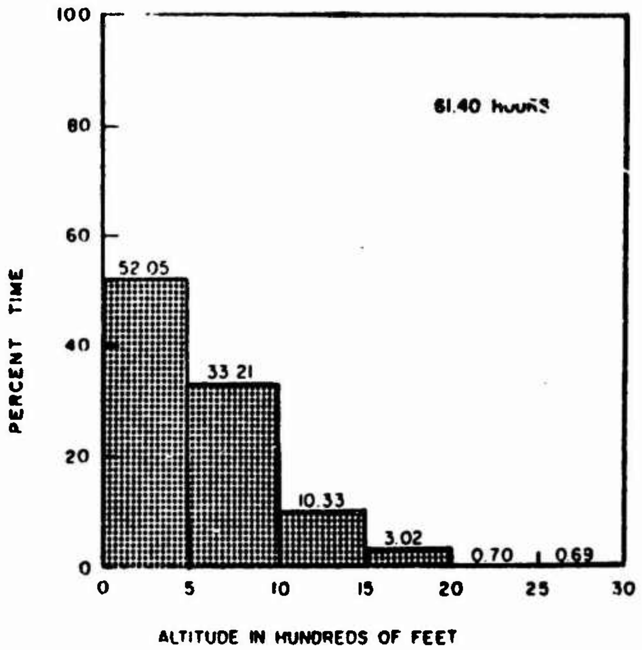


Mission Segment Takeoff and Ascent

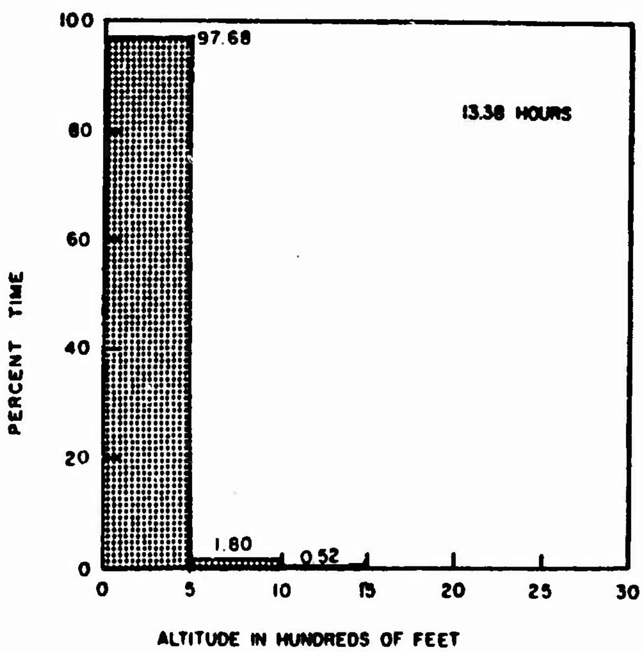


Mission Segment Cruise

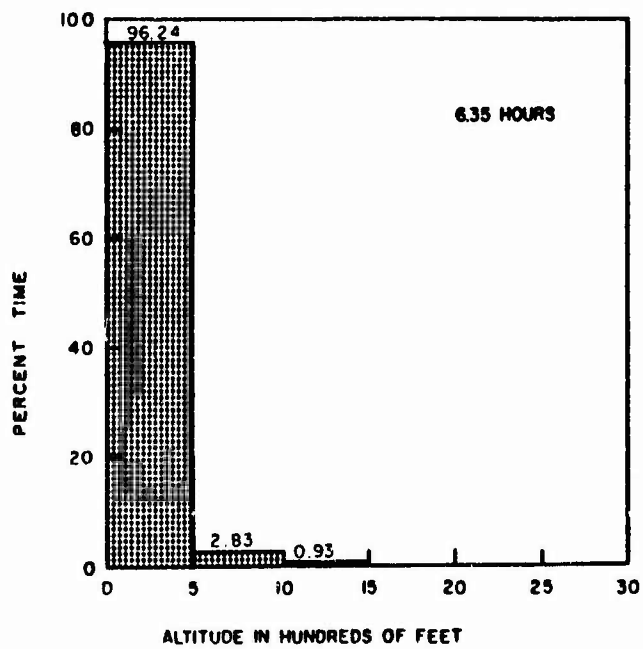
Figure 2 Percentages of Flight Time Spent at Altitude Ranges



Mission Segment Descent

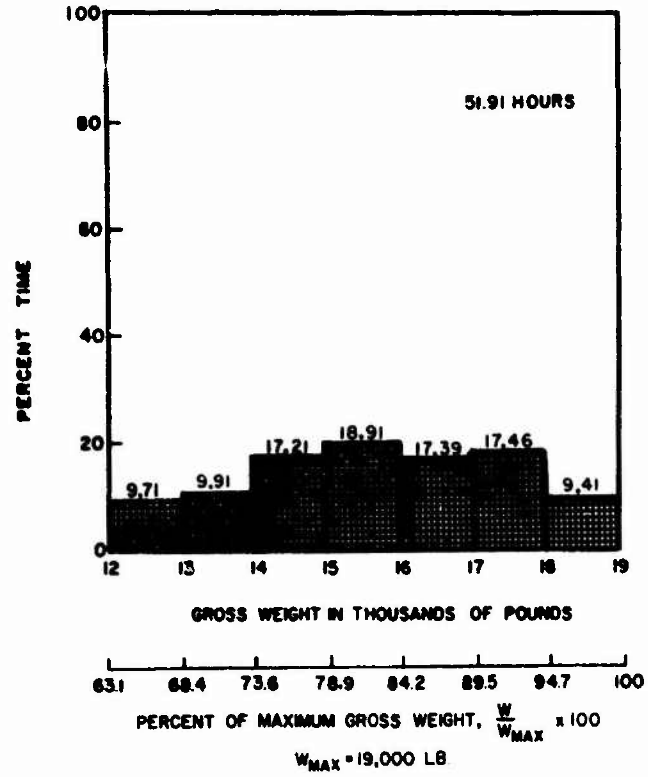


Mission Segment Flare and Landing

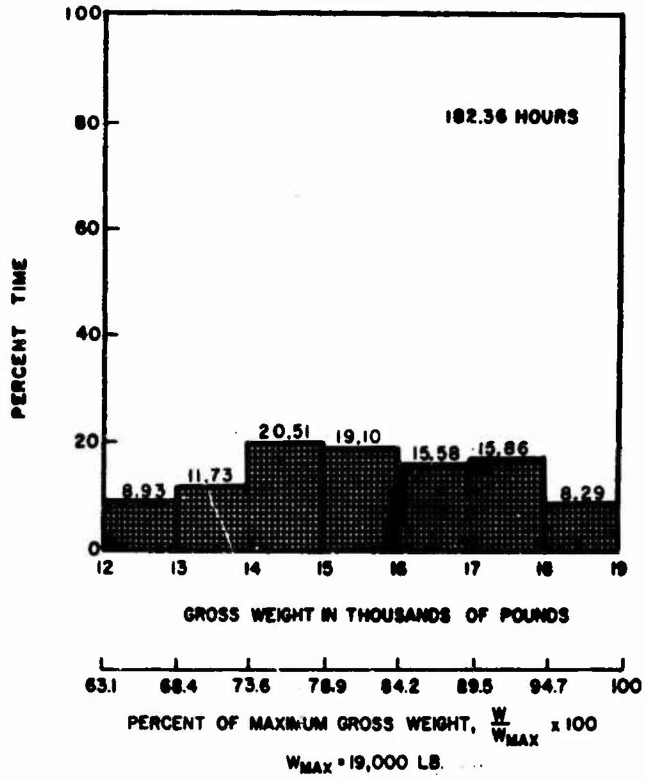


Mission Segment Hover

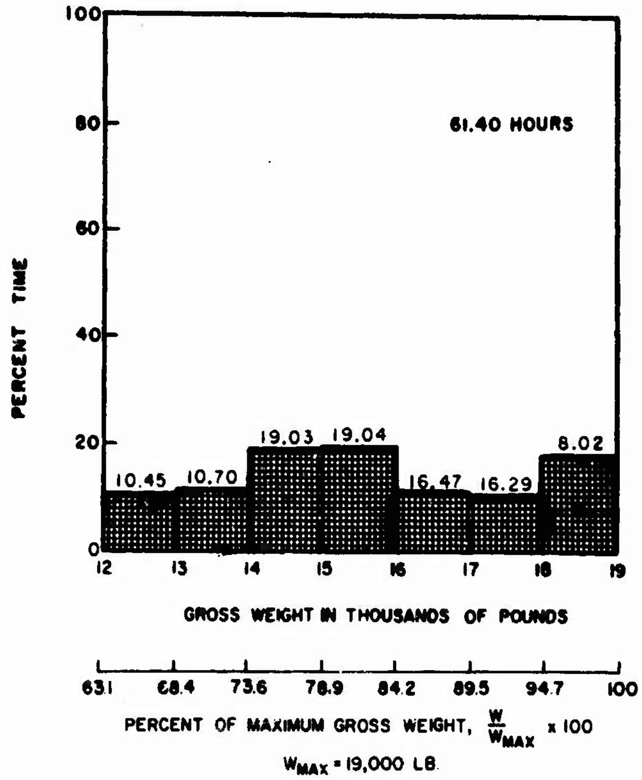
Figure 2 (cont'd.)



Mission Segment Takeoff and Ascent

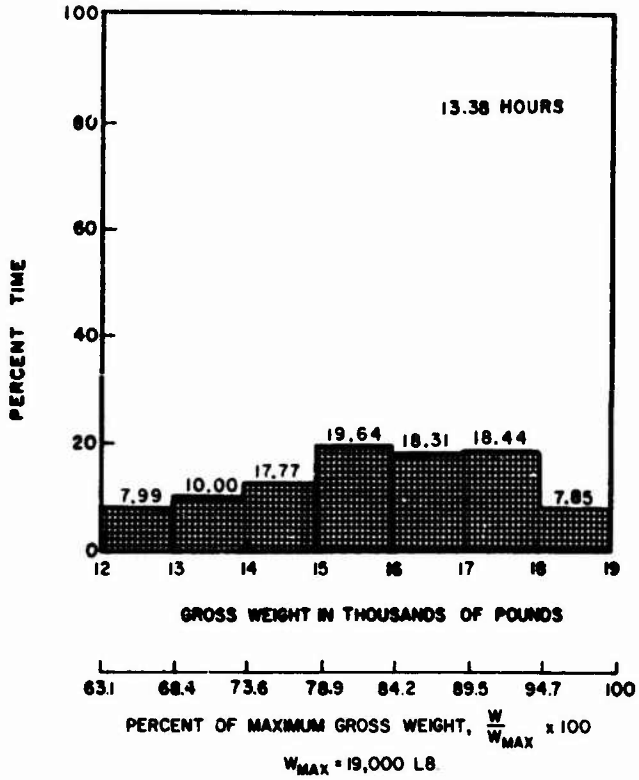


Mission Segment Cruise

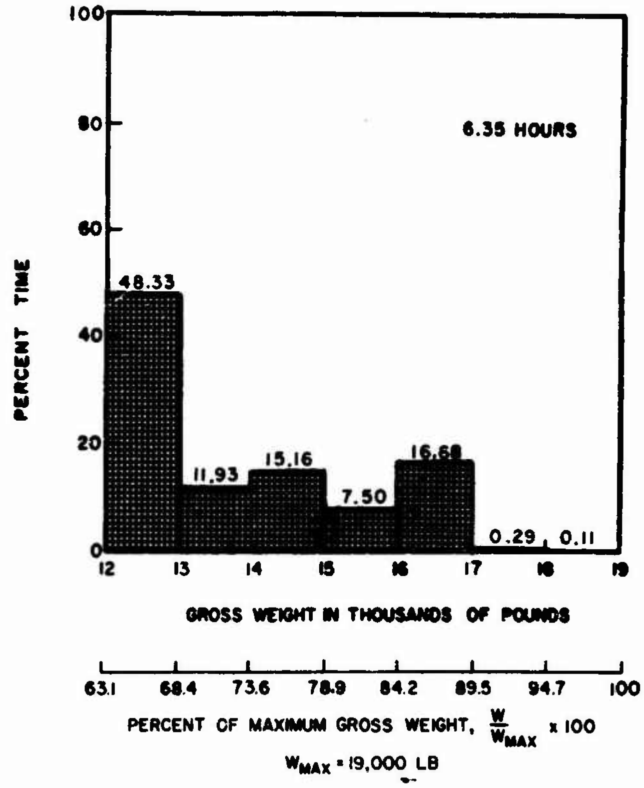


Mission Segment Descent

Figure 3 Percentages of Flight Time Spent at Gross Weight Ranges

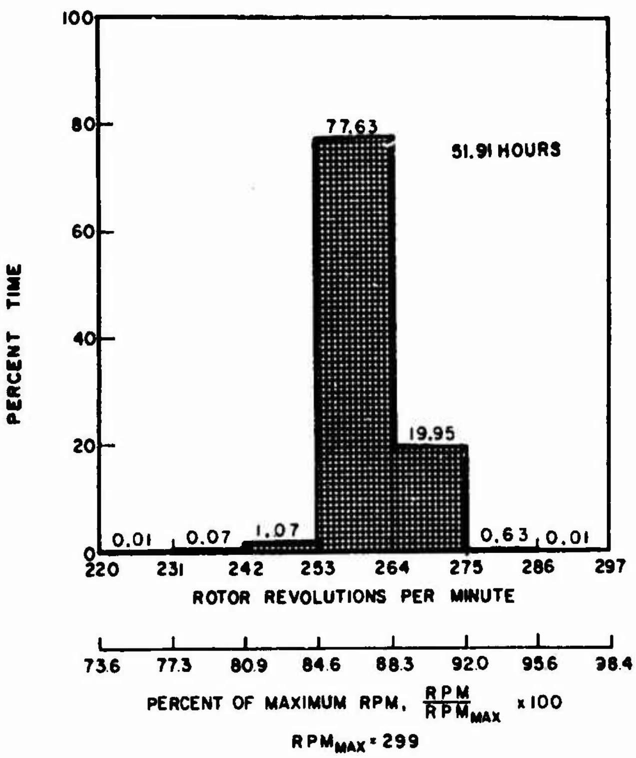


Mission Segment Flare and Landing

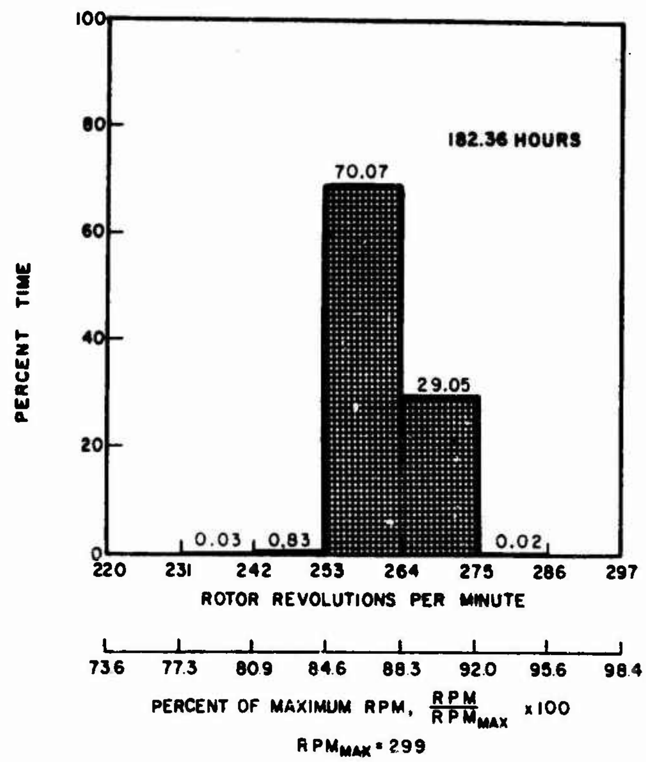


Mission Segment Hover

Figure 3 (cont'd.)

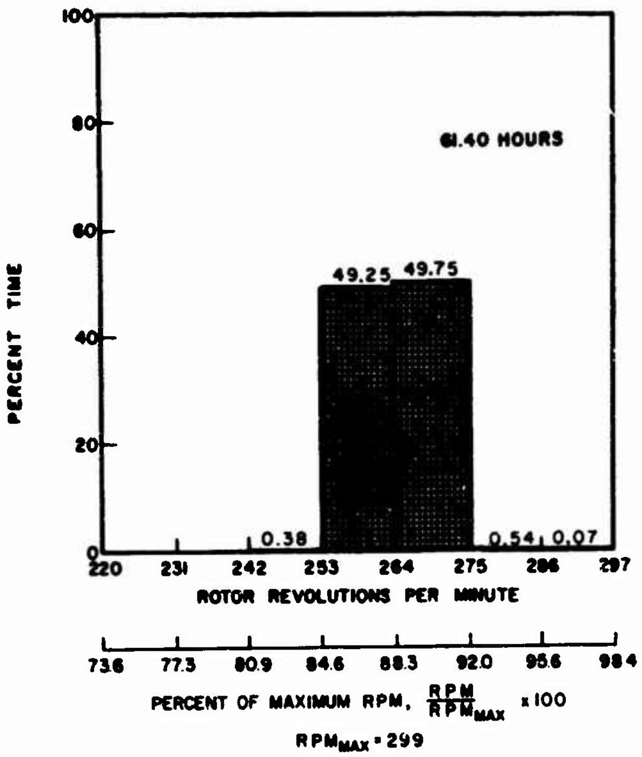


Mission Segment Takeoff and Ascent

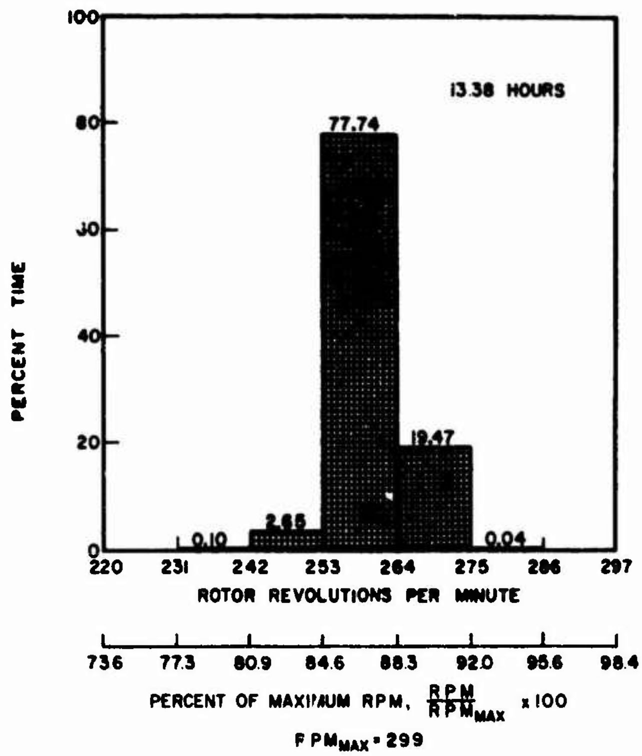


Mission Segment Cruise

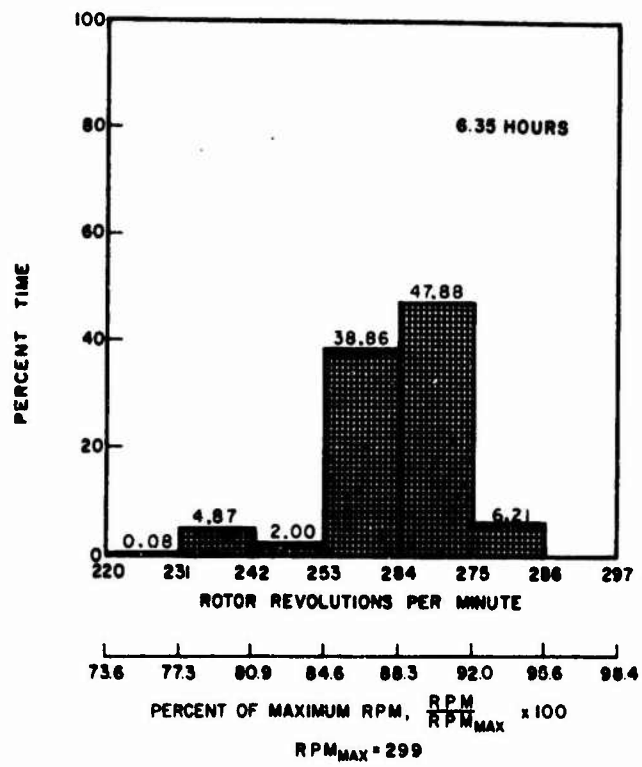
Figure 4 Percentages of Flight Time Spent at Rotor RPM Ranges



Mission Segment Descent

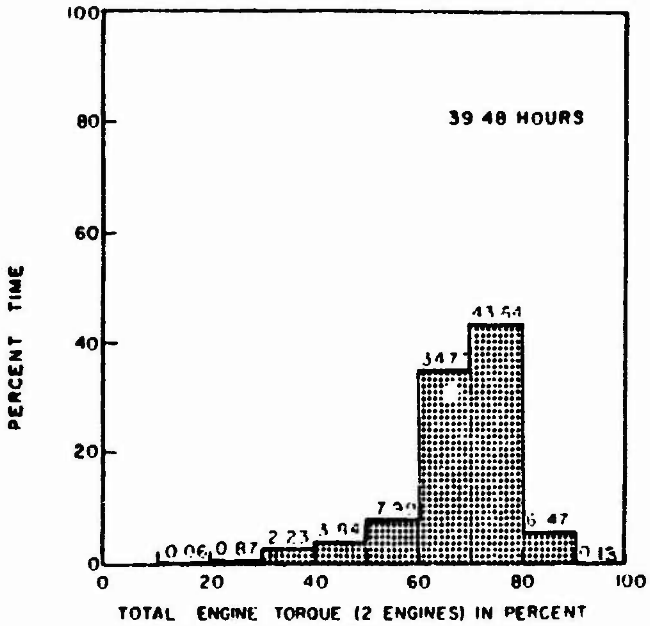


Mission Segment Flare and Landing

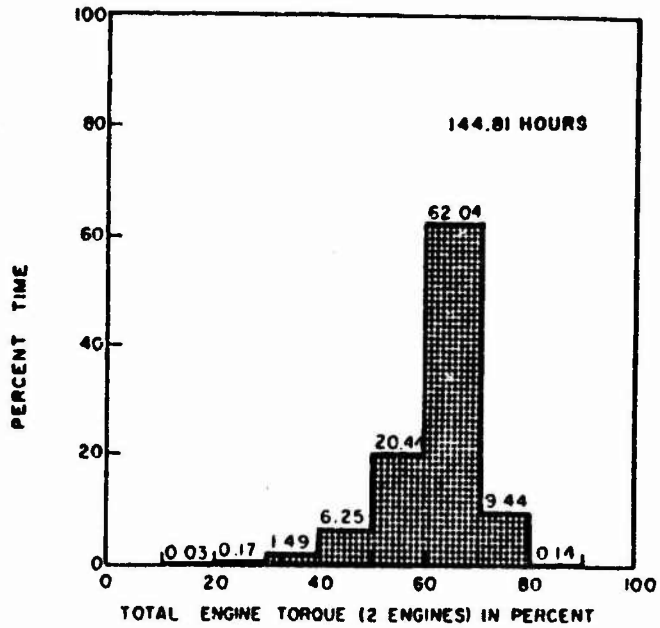


Mission Segment Hover

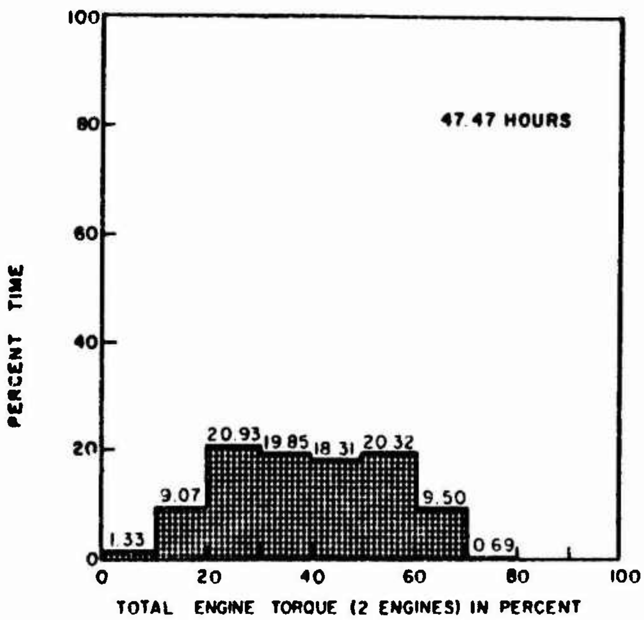
Figure 4 (cont'd.)



Mission Segment Takeoff and Ascent

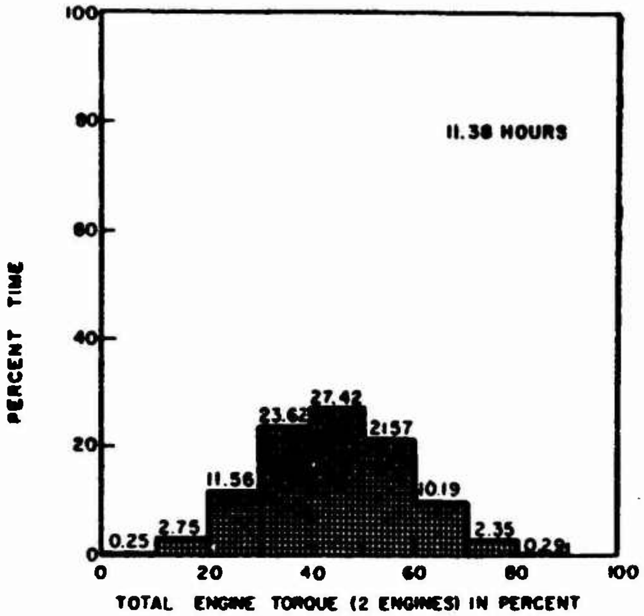


Mission Segment Cruise

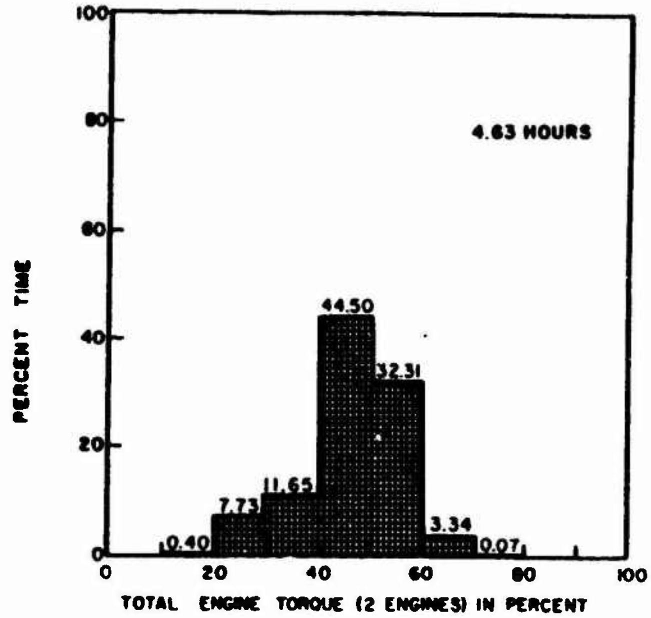


Mission Segment Descent

Figure 5 Percentages of Flight Time Spent at Engine Torque Ranges

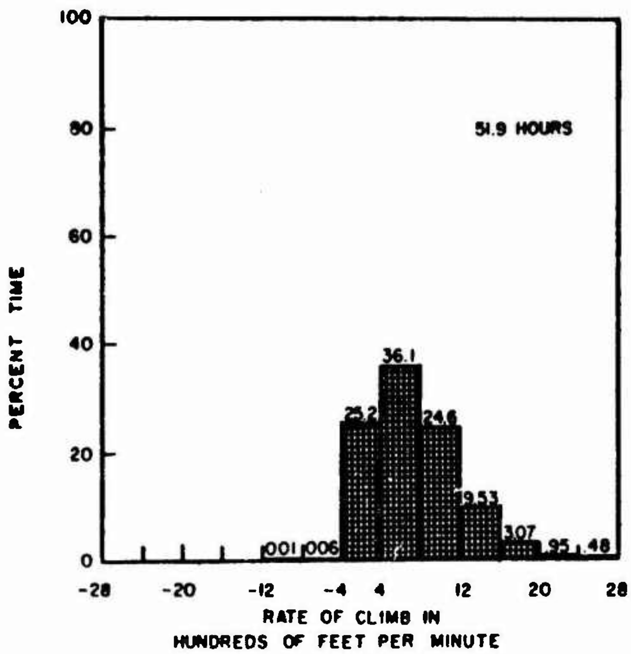


Mission Segment Flare and Landing

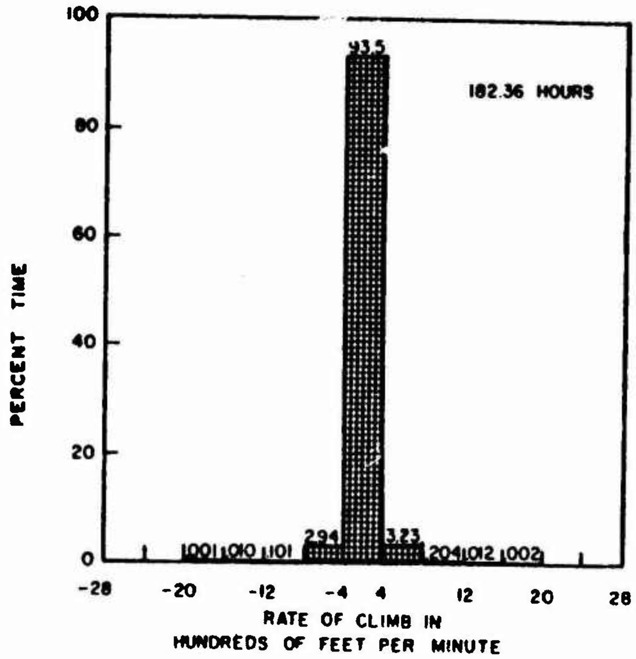


Mission Segment Hover

Figure 5 (cont'd.)

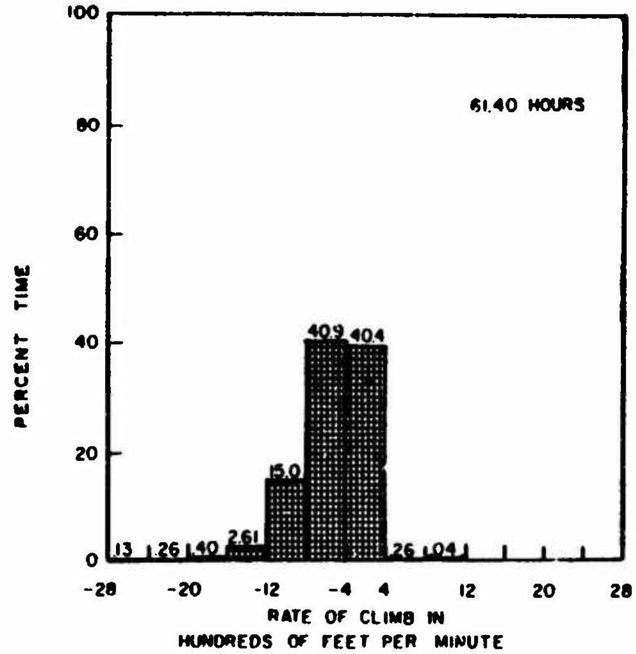


Mission Segment Takeoff and Ascent

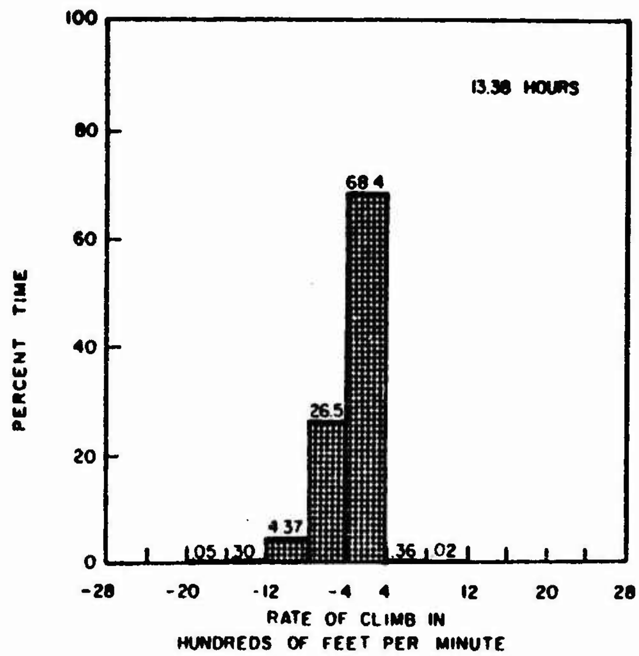


Mission Segment Cruise

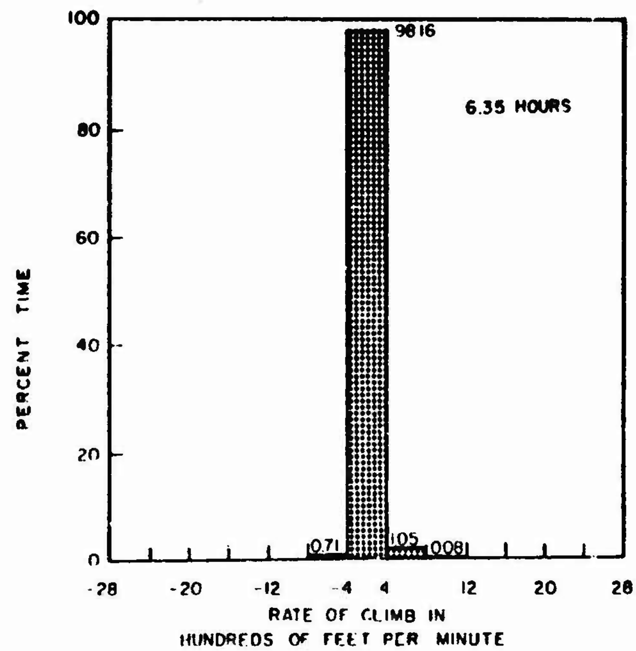
Figure 6 Percentages of Flight Time Spent at Rate-of-Climb Ranges



Mission Segment Descent



Mission Segment Flare and Landing



Mission Segment Hover

Figure 6 (cont'd.)

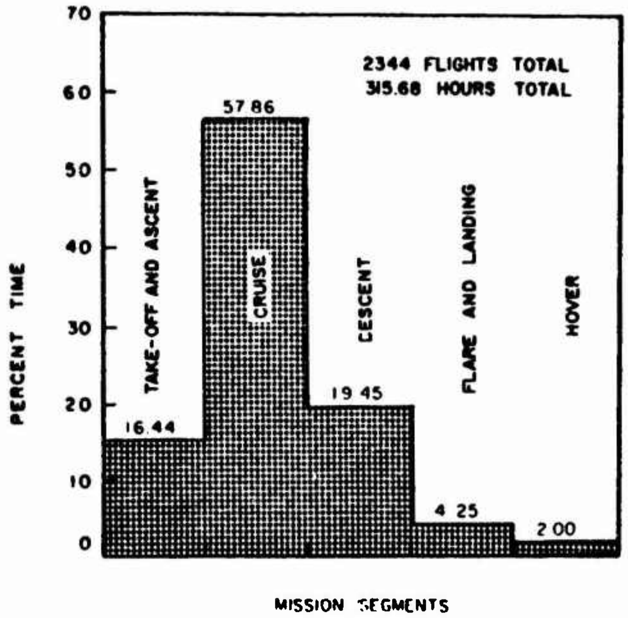


Figure 7 Percentages of Flight Time Spent in Each Mission Segment

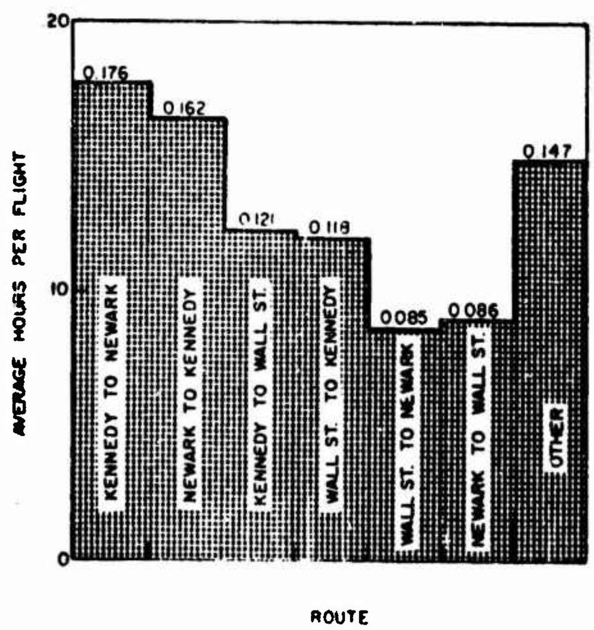
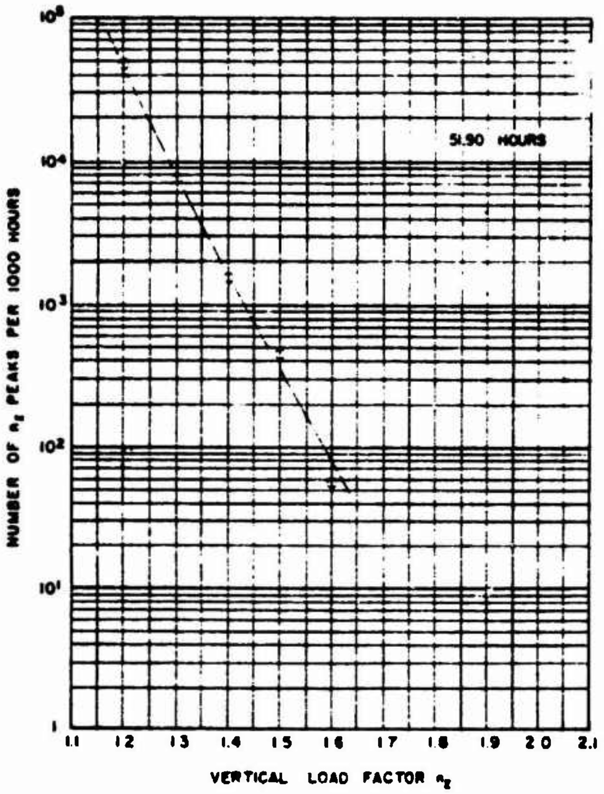
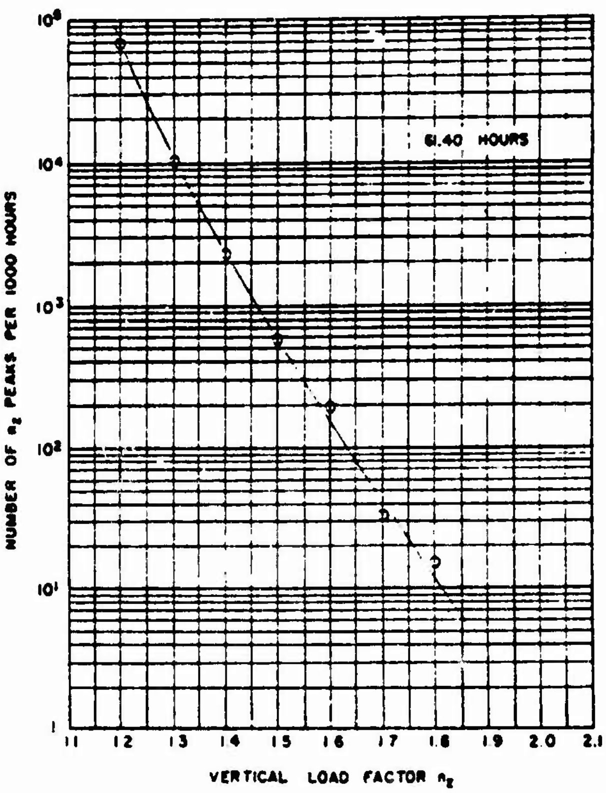


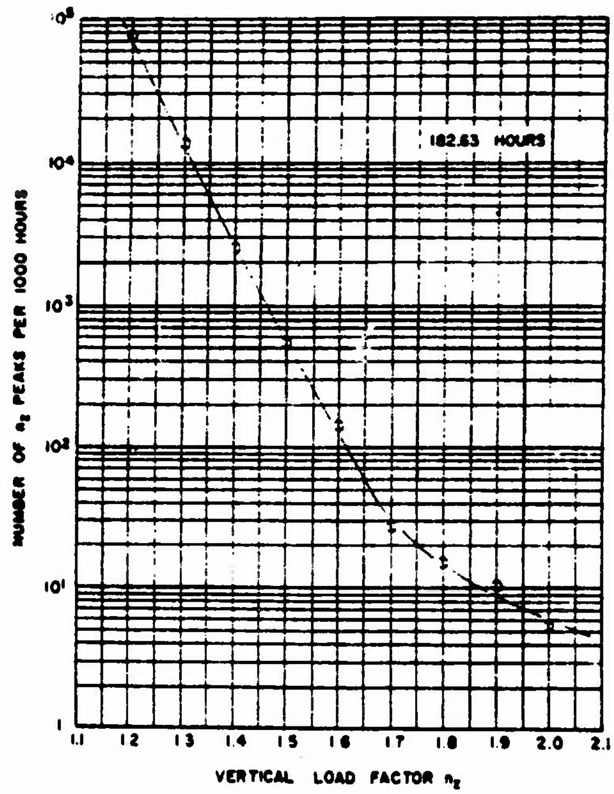
Figure 8 Average Time Per Flight by Route



Mission Segment Takeoff and Ascent

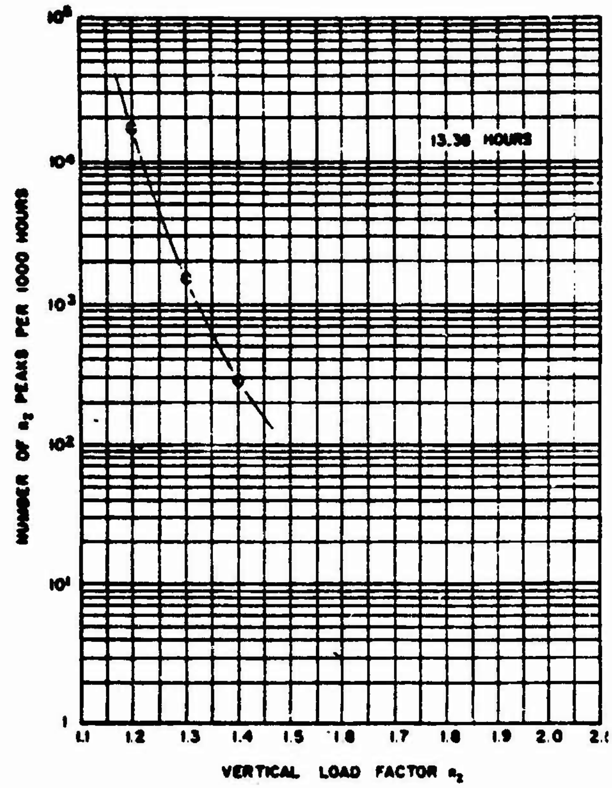


Mission Segment Descent

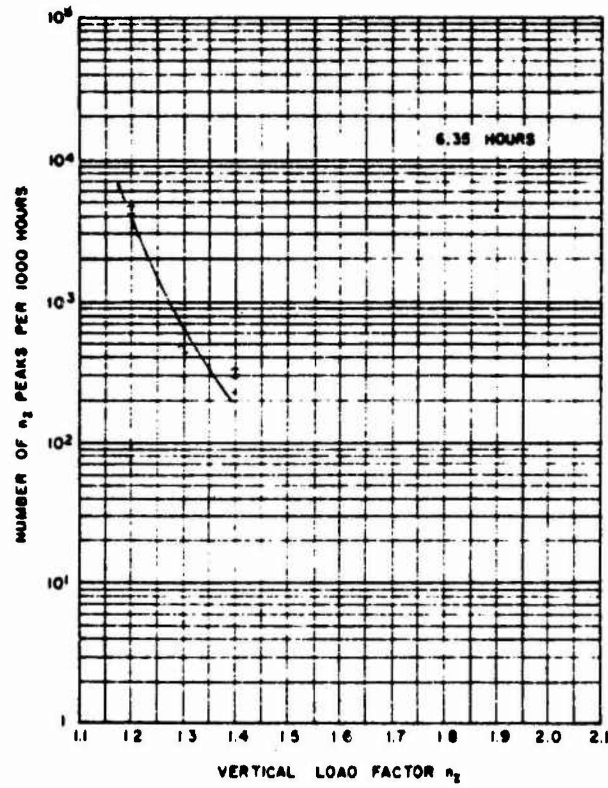


Mission Segment Cruise

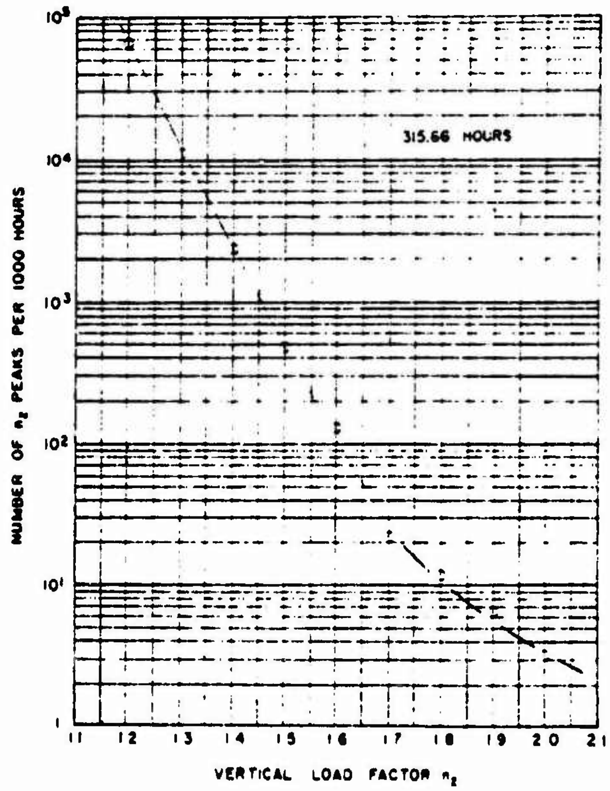
Figure 9 Vertical Load Factor, n_z, Exceedance Curves



Mission Segment Flare and Landing

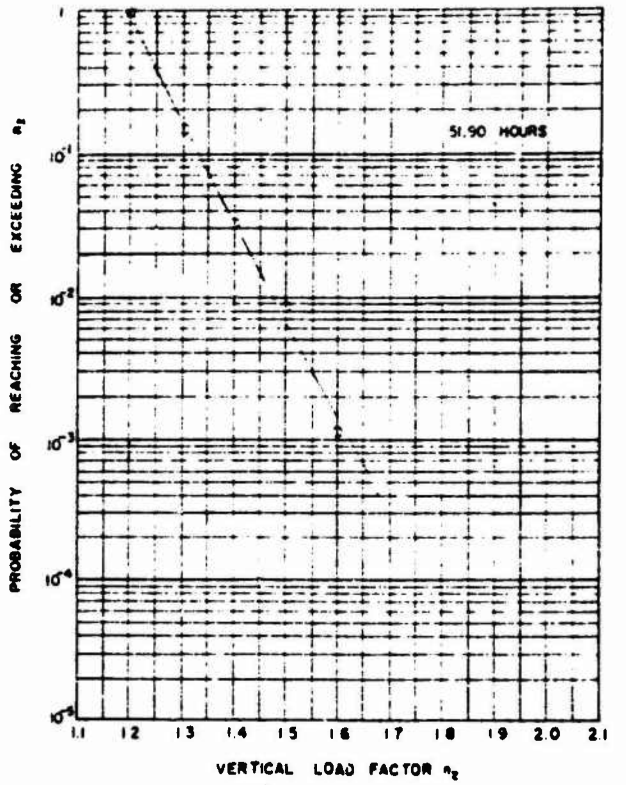


Mission Segment Hover

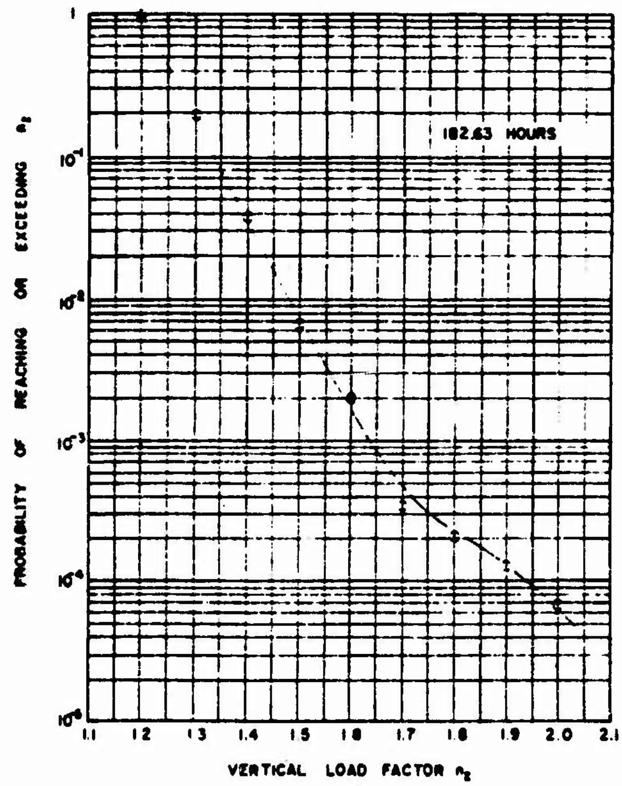


Mission Segment Composite

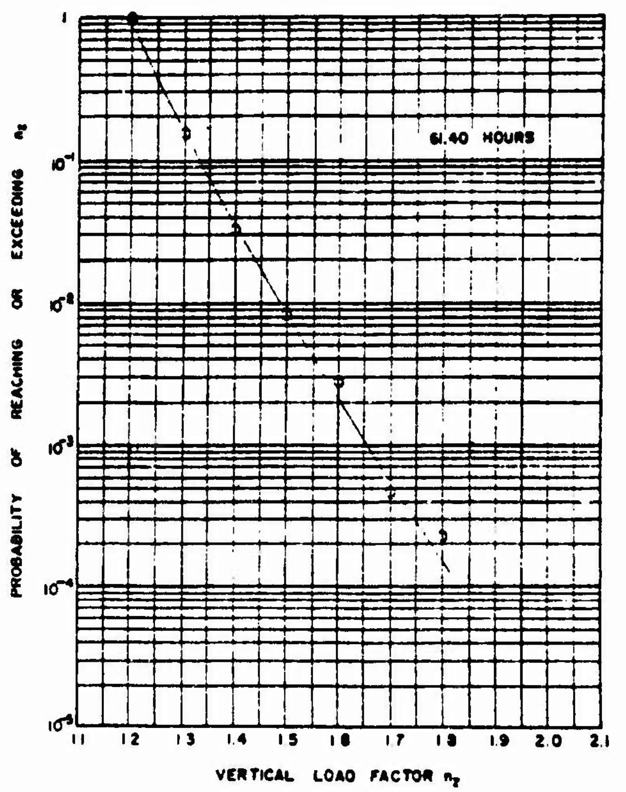
Figure 9 (cont'd.)



Mission Segment Takeoff and Ascent

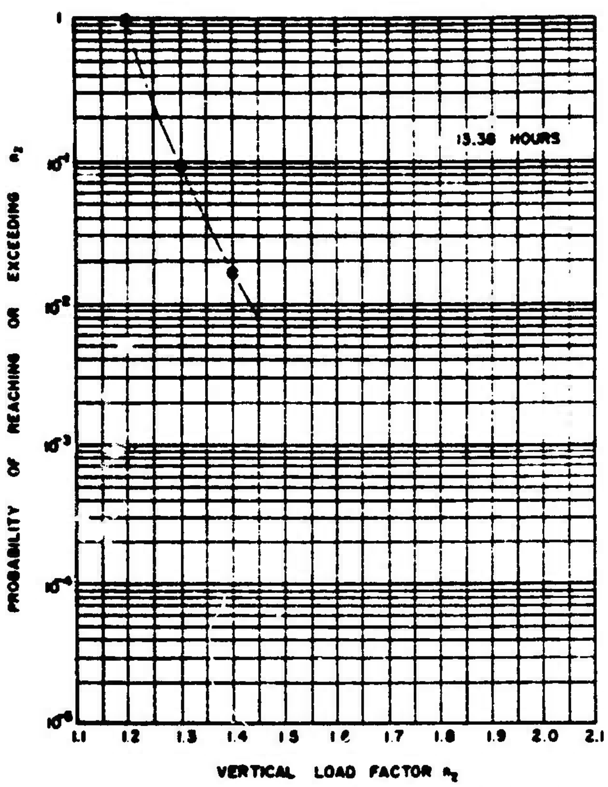


Mission Segment Cruise

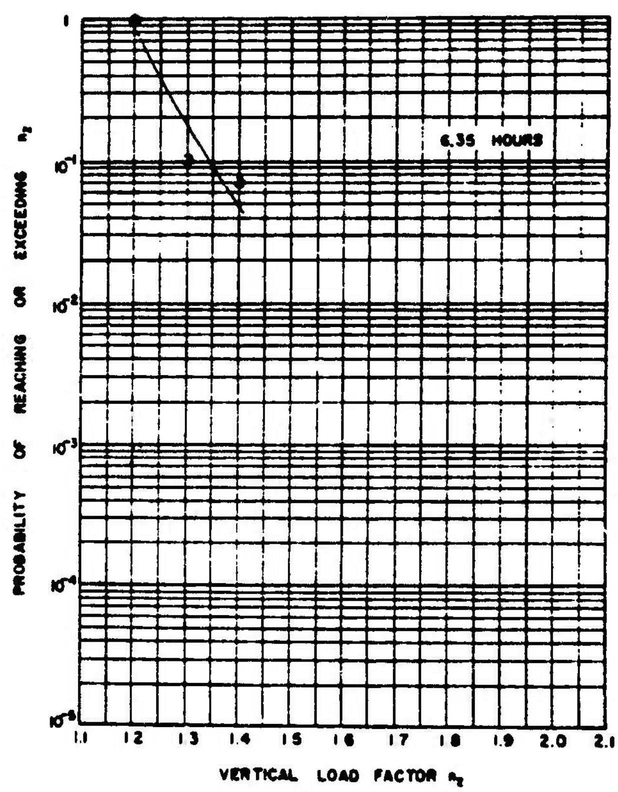


Mission Segment Descent

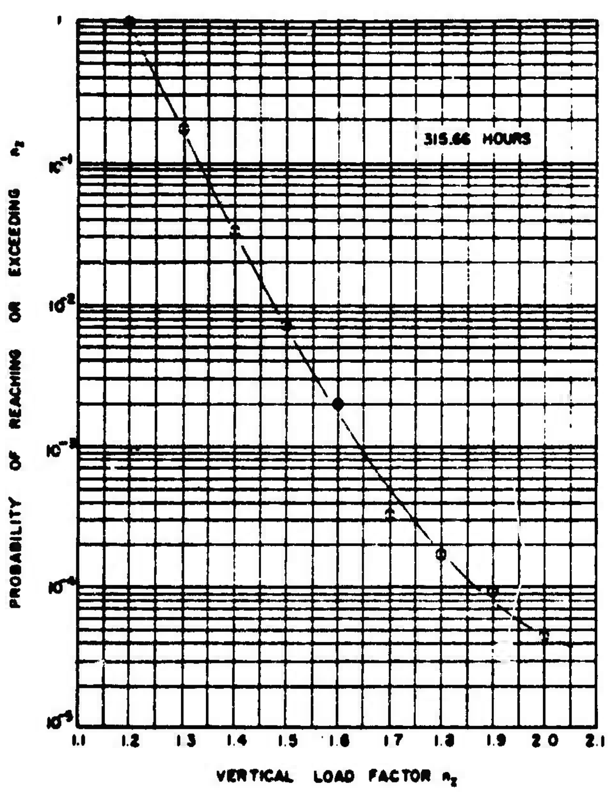
Figure 10 Probability of Reaching or Exceeding Vertical Load Factor, n_z



Mission Segment Flare and Landing

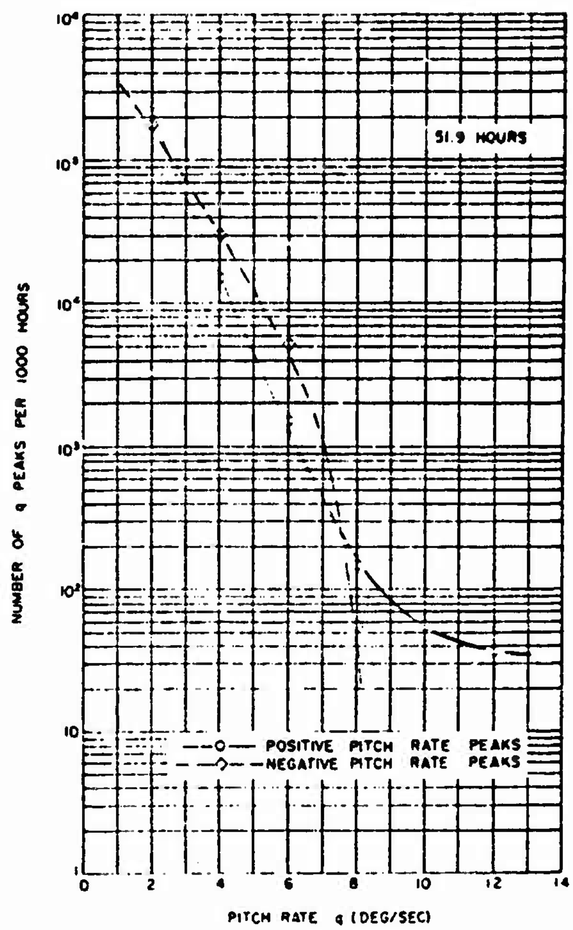


Mission Segment Hover

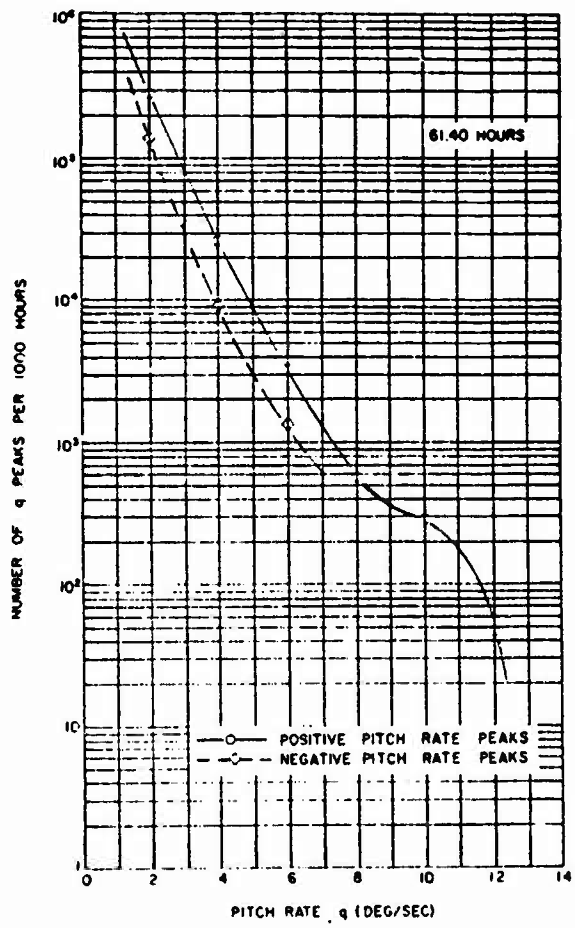


Mission Segment Composite

Figure 10 (cont'd.)

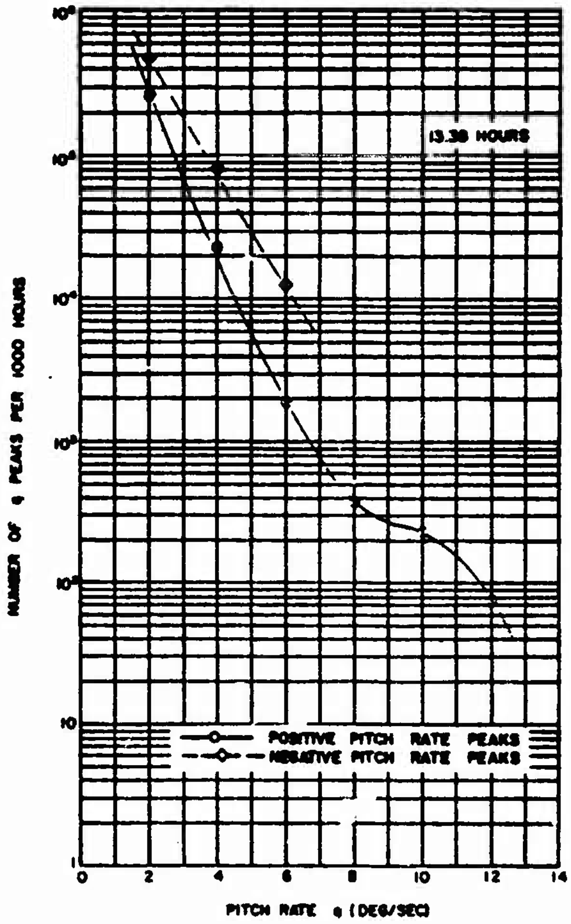


Mission Segment Takeoff and Ascent

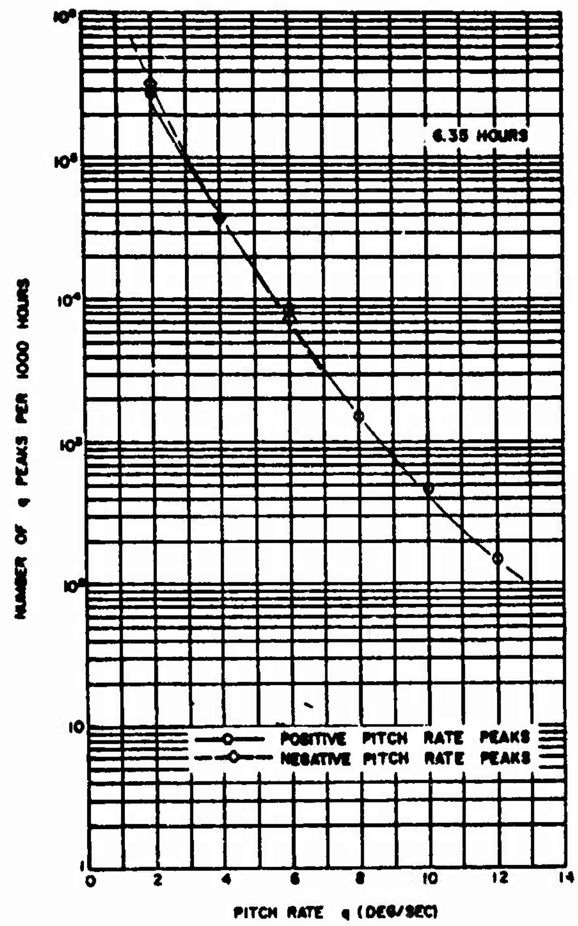


Mission Segment Descent

Figure 11 Pitch Rate, q, Exceedance Curves

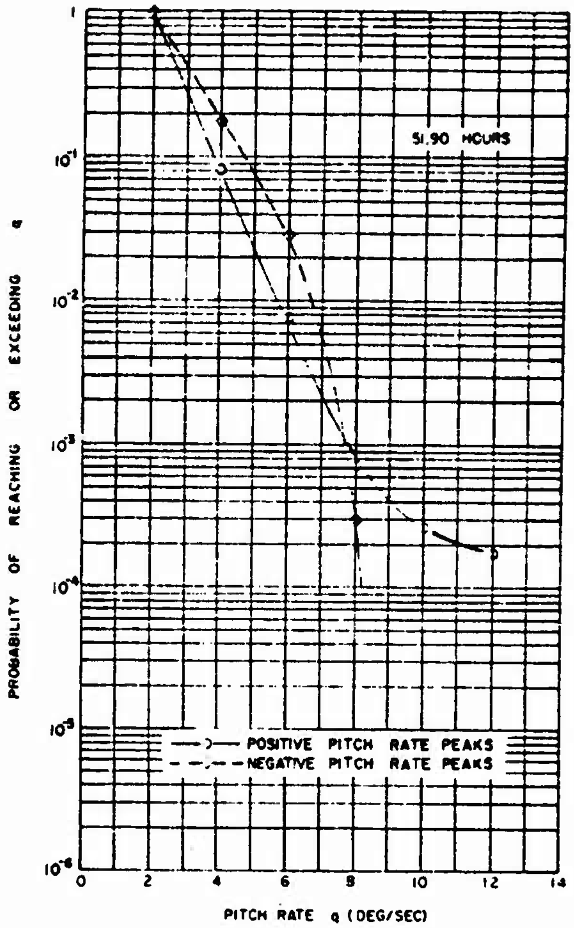


Mission Segment Flare and Landing

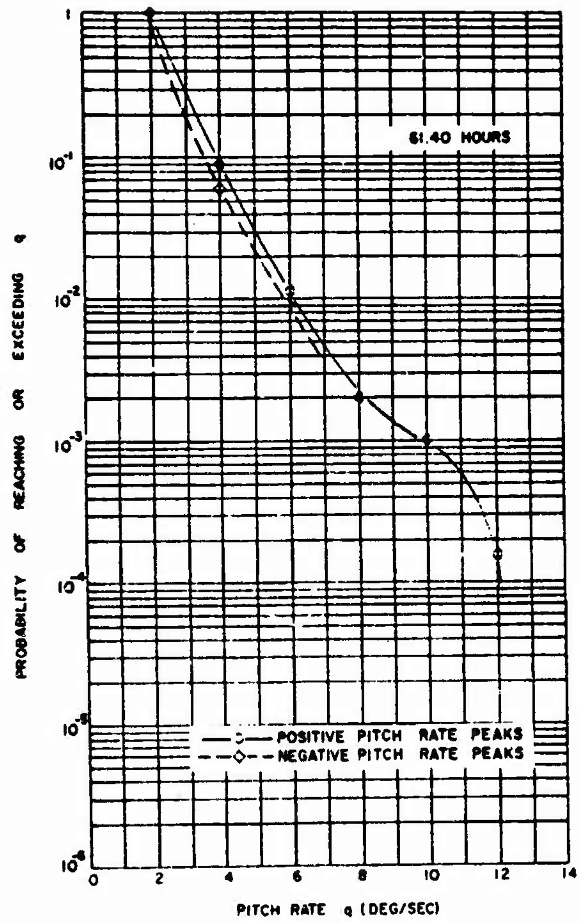


Mission Segment Hover

Figure 11 (cont'd.)

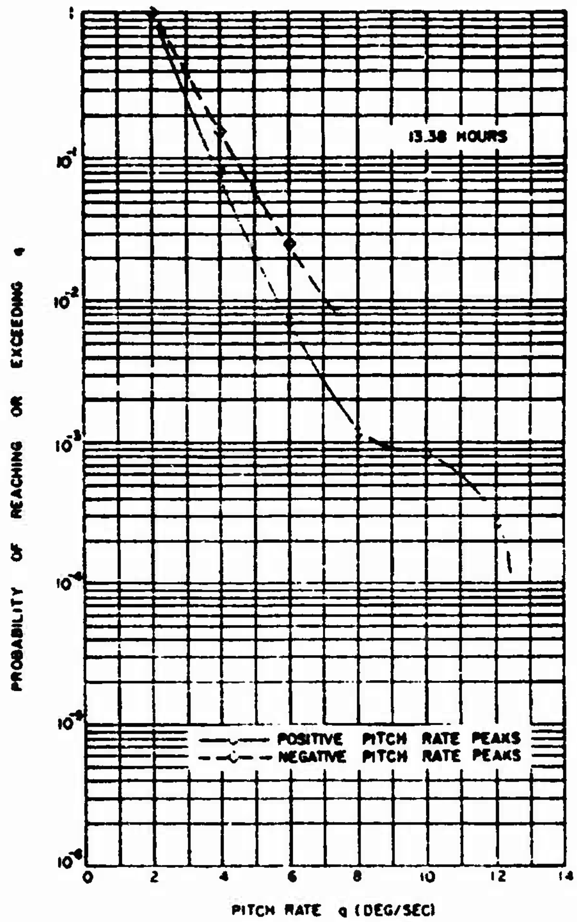


Mission Segment Takeoff and Ascent

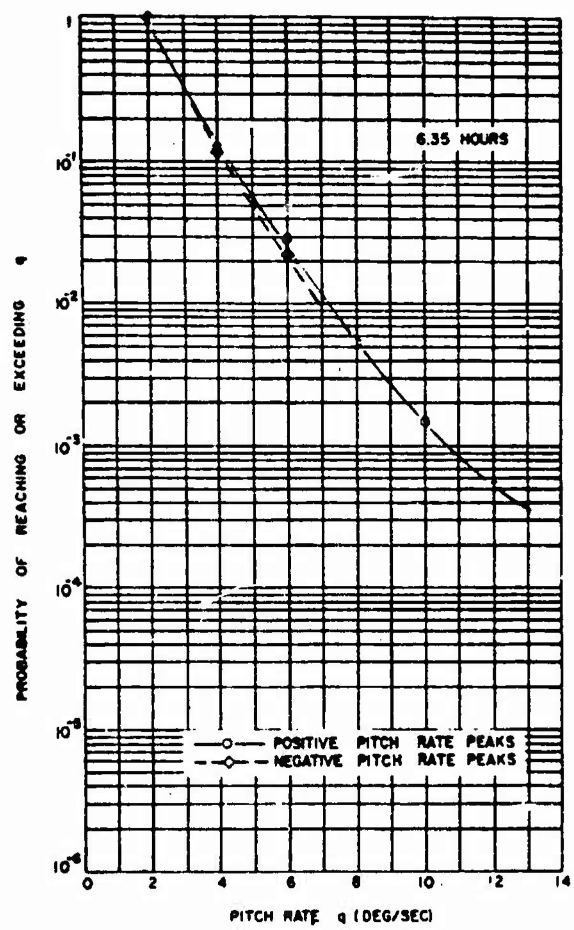


Mission Segment Descent

Figure 12 Probability of Reaching or Exceeding Pitch Rate, q

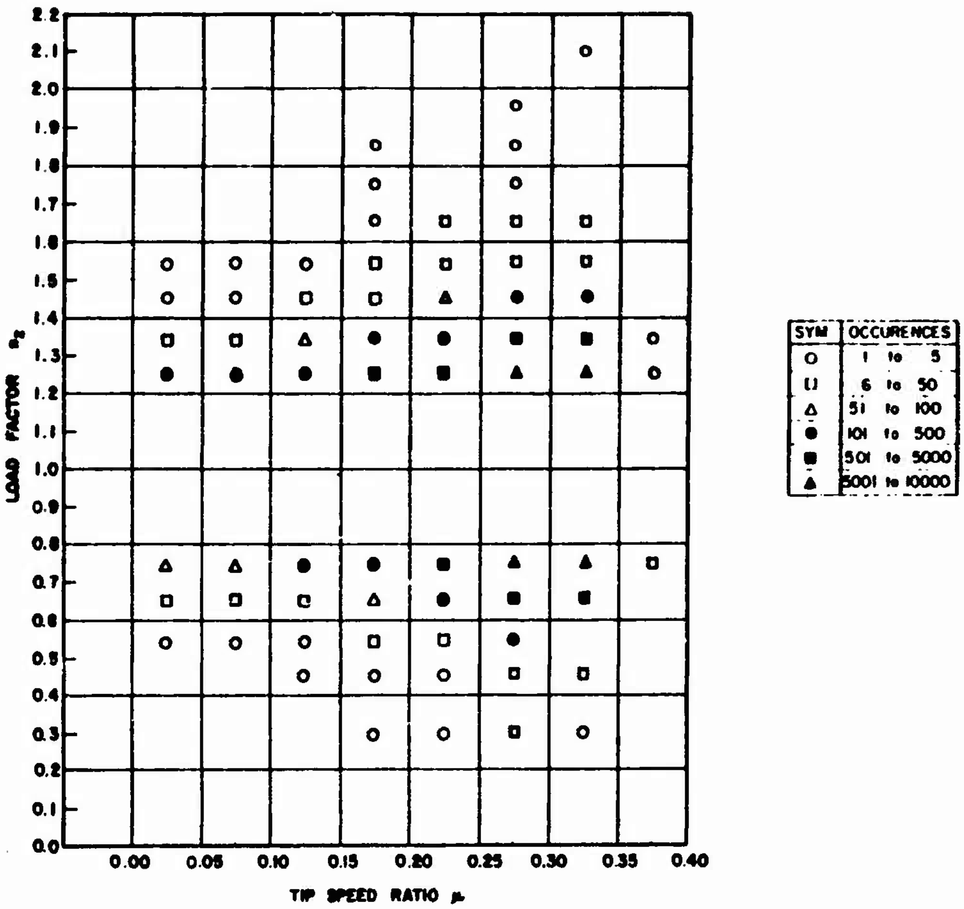


Mission Segment Flare and Landing



Mission Segment Hover

Figure 12 (cont'd.)



LOAD FACTOR n_z	TIP SPEED RATIO μ LESS THAN 0.00	0.00 to 0.05	0.05 to 0.10	0.10 to 0.15	0.15 to 0.20	0.20 to 0.25	0.25 to 0.30	0.30 to 0.35	0.35 to 0.40	TOTAL
2.0 to 2.2								1		1
1.9 to 2.0							1			1
1.8 to 1.9					1		1			2
1.7 to 1.8					1		2			3
1.6 to 1.7					2	6	17	12		37
1.5 to 1.6		1	1	1	6	26	39	36		110
1.4 to 1.5		5	1	6	29	68	205	232		546
1.3 to 1.4		10	15	67	171	331	1141	1375	3	3113
1.2 to 1.3		191	218	366	957	1816	5920	8043	5	17518
0.8 to 1.2										0
0.7 to 0.8		69	59	119	426	1075	5253	6293	7	13301
0.6 to 0.7		21	13	16	70	204	1046	1101		2471
0.5 to 0.6		4	1	1	10	24	188			416
0.4 to 0.5				1	1	5	37	24		70
0.2 to 0.4					1	1	7	5		14
0.0 to 0.2										0
TOTAL	0	301	306	579	1675	3556	13657	17312	15	37603

Figure 13 Tip Speed Ratio, μ , versus Vertical Load Factor n_z

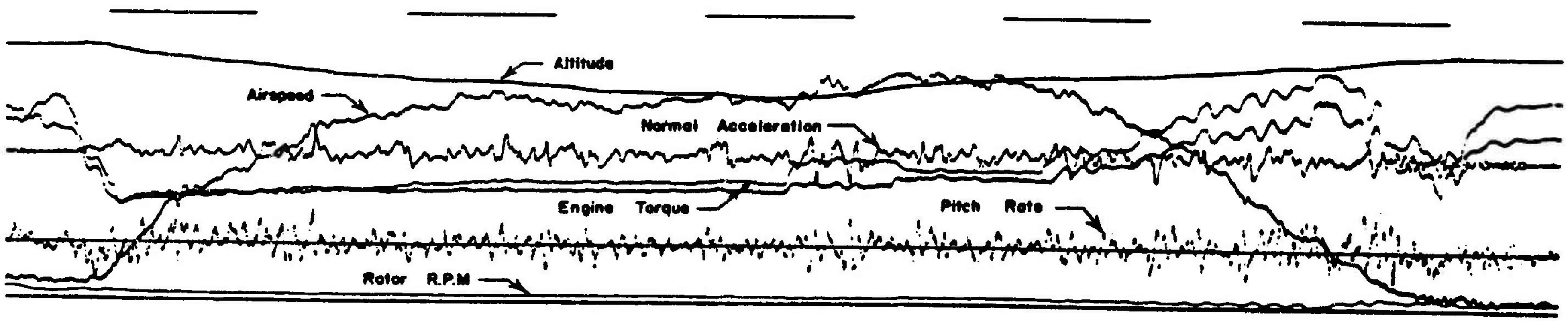
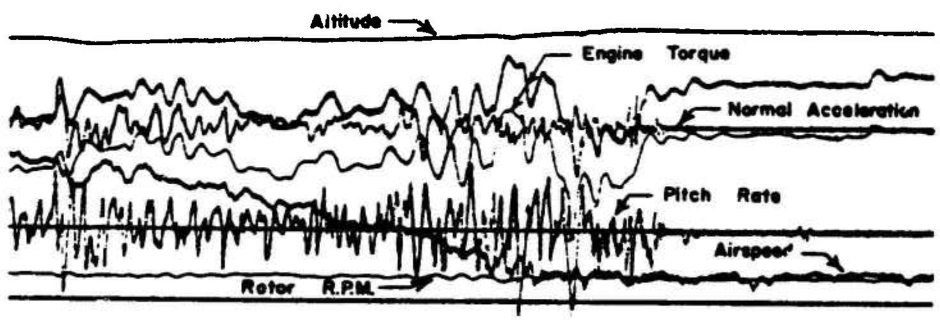
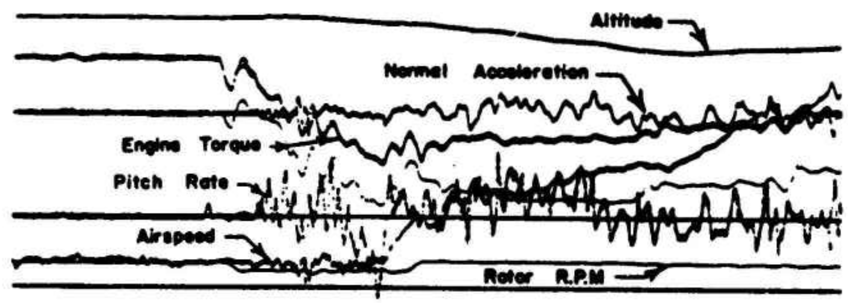


Figure 14 Representative Flight Record
Vertol 107-II Helicopter



Landing



Takeoff

Figure 15 Test Flight Record - Landing
and Takeoff from Pan American
Building

Table II

Flight Time and Number of Flights by Route

	ROUTES								
	1(K-W)	2(N-K)	3(K-W)	4(W-K)	5(W-N)	6(N-W)	7(TEST)	8(MISC)	COMPOSITE
TOTAL HOURS	68.97	58.27	29.12	28.69	22.06	23.00	85.58	0.	315.68
HOURS/FLIGHT	0.176	0.162	0.121	0.118	0.085	0.086	0.147	0.	0.135
TOTAL FLIGHTS	391	360	240	244	260	267	582	0	2344

K - Kennedy; N - Newark; W - Wall Street

Table III

Pitch Rate Peaks by Mission Segment and Totals

PITCH RATE PEAKS

Mission Segment	BELOW	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	TOTAL
TO-ASC			3	268	1374	7393			10191	830	78	5	1	2	20145
CRUISE															
DESCNT				31	479	8374			16358	1395	193	18	15	3	26916
FLR-LD				173	917	5364			3286	274	21	2	2	1	10040
HOVER				47	203	1831			1615	190	45	7	2	1	3941
TOTAL			3	559	2973	22962			31450	2689	337	32	20	7	61042

Table IV

Delta n_z Peaks by Mission Segment and Totals

PEAK DELTA NZ MANEUVERS

Mission Segment	-0.8	-0.6	-0.5	-0.4	-0.3	-0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	TOTAL
TO-ASC	3	7	41	206	1199		2047	311	60	18	3					3895
CRUISE	10	44	295	1836	9574		11703	2207	374	68	24	2	1	1	1	26140
DESCNT	1	19	76	406	2441		3531	576	106	24	10	1	1			7192
FLR-LD			1	7	57		212	18	4							299
HOVER			3	16	30		25	1	2							77
TOTAL	14	70	416	2471	13301		17518	3113	546	110	37	3	2	1	1	37603

Table V

Delta n_z Peaks by Pitch Rate for Cruise Segment

CRUISE SEGMENT PEAK DELTA NZ MANEUVERS

Pitch Rate - °/sec	-0.8	-0.6	-0.5	-0.4	-0.3	-0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	TOTAL
BELOW																
-12.0																
-10.0																
-8.0	1	4	12	20	10		1									48
-6.0	7	21	94	246	289											657
-4.0	1	18	170	1324	5994		2	1								7510
-2.0	1	1	18	245	3254		7	1								3527
0.0			1		24		4343	225	11	1	3					4608
2.0				1	3		6877	1610	207	24	2	1				8725
4.0							431	329	130	30	9					929
6.0							38	39	23	9	7		1		1	118
8.0							2	2	2	3	2	1				12
10.0							1		1	1						3
12.0							1				1			1		3
TOTAL	10	44	295	1836	9574		11703	2207	374	68	24	2	1	1	1	26140

Table VI

Flight Time (Minutes Spent in Altitude Ranges versus Mission Segment and Totals

Altitude Feet	Mission Segment TO-ASC	CRUISE	DESCENT	FLR-LND	HOVER	TOTAL
BELOW	1970.0	1689.1	1917.6	785.1	367.0	6728.6
500	806.7	5646.1	1223.3	14.5	10.8	7701.5
1000	240.8	2790.3	380.5	4.1	3.5	3419.2
1500	60.0	611.9	111.1			783.0
2000	17.1	162.7	25.8			205.6
2500	19.3	58.0	25.6			102.9
TOTAL	3113.9	10958.1	3684.0	803.8	381.3	18941.1

Table VII

Flight Time (Minutes) Spent in Airspeed Ranges versus Mission Segment and Totals

Airspeed Knots	Mission Segment TO-ASC	CRUISE	DESCENT	FLR-LND	HOVER	TOTAL
BELOW	474.2	10.3	49.3	691.4	381.2	1626.5
40.0	235.7	23.8	288.3	100.4		648.3
60.0	506.7	183.0	535.7	11.9		1237.3
80.0	911.5	554.0	576.8	0.1		2042.5
100.0	823.4	3082.6	1051.9			4958.0
120.0	162.4	7091.0	1159.5			8413.0
140.0		13.2	2.3			15.5
TOTAL	3114.0	10958.1	3684.1	803.8	381.3	18941.2

Table VIII

Flight Time (Minutes) Spent in Rotor RPM Ranges versus Mission Segment and Totals

Rotor RPM	Mission Segment TO-ASC	CRUISE	DESCENT	FLR-LND	HOVER	TOTAL
BELOW	0.3				0.3	0.7
231	2.2	3.0	0.1	0.8	18.6	24.6
242	52.9	91.3	14.1	21.2	7.8	187.3
253	2417.6	7678.1	1814.3	624.9	148.2	12683.1
264	621.1	3182.9	1832.3	156.4	182.6	5975.4
275	19.6	2.8	20.0	0.3	23.7	66.4
286	0.1		2.8			2.9
297			0.3	0.1		0.4
TOTAL	3113.9	10958.0	3684.0	803.8	381.3	18941.0

Table IX

Flight Time (Minutes) Spent in Torque Ranges versus Mission Segment and Totals

Percent Torque	Mission Segment: TO-ASC	CRUISE	DESCENT	FLR-LND	HOVER	TOTAL
0.0		0.1	37.8	1.7		39.6
10.0	1.5	2.5	257.4	18.8	1.1	281.2
20.0	20.6	14.5	594.1	78.9	21.5	729.7
30.0	53.0	129.5	563.6	151.3	32.4	939.9
40.0	91.0	542.6	519.7	187.2	123.8	1464.3
50.0	189.3	1776.4	576.7	147.3	89.9	2779.8
60.0	823.6	5390.5	269.7	69.5	9.3	6562.7
70.0	1033.8	820.0	19.6	16.0	0.2	1889.6
80.0	153.3	12.3		2.0		167.6
90.0	3.0	0.4		0.0		3.4
100.0						
TOTAL	2369.3	8688.8	2838.8	682.9	278.2	14858.0

Table X

Flight Time (Minutes) Spent in Gross Weight Ranges versus Mission Segment and Totals

Gross Weight - lbs	Mission Segment: TO-ASC	CRUISE	DESCENT	FLR-LND	HOVER	TOTAL
12,000	302.4	978.9	385.1	64.2	184.3	1914.9
13,000	308.7	1285.0	394.3	80.4	45.5	2113.9
14,000	535.9	2247.7	701.0	142.8	57.8	3685.2
15,000	588.7	2093.1	701.4	157.9	28.6	3569.7
16,000	541.4	1707.7	606.8	147.2	63.6	3066.7
17,000	543.3	1738.0	600.2	148.2	1.1	3031.3
18,000	293.1	908.0	295.3	63.1	0.4	1559.9
TOTAL	3114.0	10958.3	3684.1	803.8	381.3	18941.4

Table XI

Flight Time (Minutes) Spent in Rate-of-Climb Ranges versus Mission Segment and Totals

Rate-of-Climb ft/min	Mission Segment: TO-ASC	CRUISE	DESCENT	FLR-LND	HOVER	TOTAL
BELOW			4.7			4.7
-2400			9.8			9.8
-2000		0.1	15.2	0.4		15.7
-1600		1.1	96.5	2.4		100.0
-1200	0.1	11.1	551.1	35.0		597.3
-800	2.0	321.4	1507.1	213.4	2.7	2046.6
-400	735.5	10247.5	1488.3	549.7	374.3	13445.3
400	1123.6	352.5	9.9	2.8	4.0	1492.8
800	767.3	22.5	1.5	0.1	0.3	791.7
1200	296.5	1.4				297.9
1600	95.4	0.2				95.6
2000	28.9					28.9
2400	14.7					14.7
TOTAL	3114.0	10357.5	3684.0	803.6	331.3	18940.9

Table XII

Flight Time (Minutes) Spent at Altitude Ranges versus Airspeed by Gross Weight

Gross Weight 12,000 to 13,000 lb

Altitude Feet	Airspeed - Knots LESS	40	60	80	100	120	140	TOTAL
LESS	292.4	54.9	91.1	101.3	96.6	91.5	0.2	728.1
500	15.3	5.8	22.6	97.0	211.6	250.8	0.3	603.5
1000	1.2	1.4	18.4	51.5	105.3	119.2	1.2	298.3
1500	0.5	1.0	9.1	16.5	39.5	61.1		127.7
2000	0.4		3.0	13.7	44.0	28.6		89.7
2500		0.4	5.5	20.0	26.6	14.9		67.4
TOTAL	309.8	63.5	149.8	300.2	523.7	566.1	1.7	1914.9

Gross Weight 13,000 to 14,000 lb

Altitude Feet	Airspeed - Knots LESS	40	60	80	100	120	140	TOTAL
LESS	172.2	53.9	83.6	108.9	130.1	168.5	0.8	718.1
500	2.7	5.9	23.8	82.7	255.0	509.7		879.9
1000	2.1	2.1	8.8	24.5	92.2	282.4		412.2
1500	0.2	0.2	3.1	3.4	16.2	40.0		63.2
2000	0.4		0.4	2.3	5.7	4.4		13.2
2500	0.3	0.5	0.5	12.4	13.0	0.4		27.2
TOTAL	177.9	62.7	120.3	234.4	512.3	1005.4	0.8	2113.9

Gross Weight 14,000 to 15,000 lb

Altitude Feet	Airspeed - Knots LESS	40	60	80	100	120	140	TOTAL
LESS	266.0	105.1	161.4	187.2	232.5	318.1		1270.3
500	4.1	6.0	31.7	94.2	384.7	1016.4	0.1	1537.2
1000	8.7	3.0	10.9	31.3	187.3	408.2		649.5
1500		1.7	5.4	13.8	82.4	91.8		195.0
2000				0.9	14.8	14.9		30.6
2500				0.3	2.1			2.4
TOTAL	278.8	115.9	209.4	327.7	903.8	1849.4	0.1	3685.2

Gross Weight 15,000 to 16,000 lb

Altitude Feet	Airspeed - Knots LESS	40	60	80	100	120	140	TOTAL
LESS	246.4	110.5	162.0	211.5	242.8	312.2	3.0	1288.5
500	11.8	7.9	22.4	82.3	372.0	1025.4	2.4	1524.4
1000	4.4	4.4	7.2	23.2	144.3	416.2	0.8	600.7
1500	0.2	1.7	2.5	8.7	48.2	72.2		133.5
2000	0.4	0.3		0.6	10.4	10.9		22.6
2500								0.
TOTAL	263.3	124.9	194.2	326.3	817.7	1837.0	6.2	3569.7

Table XII (cont'd.)

Altitude Feet	LESS	40	60	80	100	120	140	TOTAL
			Airspeed - Knots				Gross Weight 16,000 to 17,000 lb	
LESS	298.3	113.5	184.7	215.6	197.0	207.0	0.8	1217.1
500	5.1	6.1	30.8	88.9	368.3	748.8	4.6	1252.7
1000	2.9	4.2	26.9	31.0	121.4	294.2		480.6
1500		0.6	1.1	4.2	31.8	52.0	0.2	89.9
2000		0.2		0.4	14.9	4.9		20.4
2500			0.4	2.6	2.9			5.9
TOTAL	306.3	124.6	243.9	342.8	736.4	1306.9	5.6	3066.7

Altitude Feet	LESS	40	60	80	100	120	140	TOTAL
			Airspeed - Knots				Gross Weight 17,000 to 18,000 lb	
LESS	201.4	101.6	183.4	191.3	197.7	159.7	1.1	1036.5
500	0.8	3.6	27.4	117.5	419.5	716.1	0.1	1285.0
1000		0.5	2.0	24.7	210.7	342.7		580.4
1500				2.1	58.5	58.4		119.1
2000				0.5	7.9	1.8		10.2
2500								0.
TOTAL	202.2	105.7	212.9	336.1	694.3	1278.8	1.2	3031.3

Altitude Feet	LESS	40	60	80	100	120	140	TOTAL
			Airspeed - Knots				Gross Weight 18,000 to 19,000 lb	
LESS	86.6	47.8	88.1	94.3	97.9	55.4		470.2
500	1.5	2.8	16.1	63.6	269.6	265.2		618.9
1000		0.4	2.3	14.6	157.2	222.8		397.4
1500			0.2	2.2	29.2	22.9		54.5
2000					15.8	3.0		18.8
2500								0.
TOTAL	88.1	51.0	106.7	174.8	569.8	569.4	0.	1559.9

Table XIII

Flight Time (Minutes) Spent at Altitude Ranges versus Airspeed

Altitude Feet	LESS	40	60	80	100	120	140	TOTAL
			Airspeed - Knots					
LESS	1563.3	587.6	954.5	1110.3	1194.7	1312.6	5.8	6729.0
500	41.4	38.2	174.9	626.3	2280.8	4532.5	7.5	7701.7
1000	19.3	15.9	76.6	201.0	1018.5	2085.9	2.0	3419.3
1500	0.9	5.2	21.4	51.0	305.8	398.4	0.2	783.0
2000	1.2	0.5	3.4	18.4	113.5	68.5		205.6
2500	0.3	0.9	6.4	35.4	44.6	15.3		102.9
TOTAL	1626.5	648.3	1237.3	2042.5	4958.1	8413.2	15.5	18941.5

Table XIV

Flight Time (Minutes) Spent in Torque Ranges versus Rotor RPM by Altitude Ranges and Outside Air Temperature Ranges

Temperature 0-20° F
Altitude 0-500 ft.

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0					0.2				0.2
10				1.0	1.8				2.8
20				4.9	6.3				11.3
30				7.6	2.9				10.5
40				9.1	3.3				12.4
50				30.1	9.6				39.7
60				15.1	9.9				25.0
70				7.2	2.1				9.4
80				0.7	0.1				0.8
90									0.
100									0.
TOTAL	0.	0.	0.	76.0	36.2	0.	0.	0.	112.2

Temperature 20-40° F
Altitude 0-500 ft.

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0				0.4	3.3	0.7	0.0		4.4
10				5.2	50.1	0.2			55.4
20			0.3	43.0	95.8	0.4			139.4
30			0.6	75.2	81.5	1.4			158.8
40		0.1	1.1	90.4	75.2	2.5			169.5
50		0.1	2.5	149.5	99.3	3.6			255.1
60			1.4	251.9	144.5	1.9			399.7
70		0.1	1.0	169.7	48.7	0.1			219.6
80			1.4	39.0	3.1				43.5
90			0.2	1.2	0.1				1.5
100									0.
TOTAL	0.	0.3	8.6	625.6	601.8	10.8	0.0	0.	1447.3

Temperature 40-60° F
Altitude 0-500 ft.

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0				0.4	8.8	1.9	0.5	0.2	11.8
10			0.2	18.5	56.5	1.3			76.6
20			1.5	100.7	114.4	1.6			218.2
30		0.2	3.1	153.8	87.2	1.6	0.4		246.5
40		1.4	9.2	203.8	72.5	4.3			291.2
50	0.3	0.4	8.1	238.1	88.6	4.2			339.8
60		0.0	4.2	393.6	53.6	0.3			451.8
70			6.0	257.8	26.5	0.3			290.6
80			0.7	41.4	2.4				44.5
90				1.5					1.5
100									0.
TOTAL	0.3	2.2	32.9	1409.9	510.7	15.6	0.9	0.2	1972.8

Temperature 60-80° F
Altitude 0-500 ft.

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0				1.9	8.6	0.5	0.2		11.2
10				31.8	52.7	1.5	0.1	0.1	86.2
20		0.0	0.8	113.2	77.4	0.8			192.3
30		0.1	1.1	135.5	57.3	0.2			194.3
40	0.1	0.3	2.4	160.3	58.1	0.4			221.7
50			1.5	200.5	37.5	1.4	0.1		241.0
60			2.6	439.8	43.0	1.2			486.6
70			2.9	279.8	19.3	0.5			302.5
80			1.3	28.1	1.5				30.9
90				0.0					0.0
100									0.
TOTAL	0.1	0.4	12.7	1391.0	355.6	6.5	0.4	0.1	1767.0

Table XIV (cont'd.)

Temperature 80-100° F
Altitude 0-500 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0				0.6	0.8				1.4
10		0.2		5.9	8.2	0.2			14.6
20		0.0	0.1	18.2	13.2				31.7
30		1.0	0.2	31.3	9.4				41.9
40		15.5	0.3	31.9	6.3				54.1
50	0.2	0.6	1.1	32.6	5.6				40.2
60		0.7	0.4	73.3	4.3				78.8
70			0.6	42.6	0.9				44.2
80		0.0	0.6	8.4					9.1
90									0.
100									0.
TOTAL	0.2	18.3	3.4	245.0	48.9	0.2	0.	0.	316.1

Temperature 0-20° F
Altitude 500-1000 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10				0.3	0.3				0.6
20				1.4	1.1				2.5
30			0.1	0.9	0.8				1.8
40				2.9	3.3				6.2
50				32.5	9.0				41.5
60				25.9	13.4				39.4
70				1.4	0.5				1.9
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.1	65.3	28.4	0.	0.	0.	93.9

Temperature 20-40° F
Altitude 500-1000 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0					0.1				0.1
10				0.5	4.5	0.1			5.1
20				9.8	19.9				29.7
30				18.5	23.0	0.9			42.5
40			0.4	51.6	38.1	0.2			90.3
50			1.5	154.2	135.4	0.2			291.3
60			1.6	654.1	315.2	0.2			971.1
70			0.4	201.3	37.2				238.9
80				12.7	1.4				14.2
90				0.0					0.0
100									0.
TOTAL	0.	0.	3.8	1103.0	575.0	1.6	0.	0.	1683.4

Temperature 40-60° F
Altitude 500-1000 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0				0.4	1.9	0.7	0.1	0.0	3.2
10				2.9	9.1	0.2			12.1
20			0.1	13.8	17.0				30.9
30			0.7	40.3	27.3				68.4
40		0.4	8.6	110.1	43.1	0.2			162.5
50		0.5	1.6	369.3	112.6	1.1			485.1
60			3.4	897.9	134.6				1035.9
70			8.0	207.5	41.5				257.0
80			0.6	6.9	0.7				8.2
90									0.
100									0.
TOTAL	0.	0.9	23.1	1649.2	387.8	2.2	0.1	0.0	2063.4

Table XIV (cont'd.)

Rotor RPM — Temperature 60-80° F, Altitude 500-1000 ft.

Percent Torque	LESS	231	242	253	264	275	286	297	TOTAL
0				0.3	1.4	0.3			2.0
10				3.2	7.8	0.8			11.8
20				14.2	20.7				35.0
30			2.1	33.5	30.8				66.4
40			2.6	106.7	53.4	0.1			162.9
50				227.1	75.4				302.5
60			3.7	991.5	169.2				1164.4
70				155.1	28.9				184.0
80				2.8	0.8				3.6
90				0.2					0.2
100									0.
TOTAL	0.	0.	8.4	1534.8	388.4	1.2	0.	0.	1932.9

Rotor RPM — Temperature 80-100° F, Altitude 500-1000 ft.

Percent Torque	LESS	231	242	253	264	275	286	297	TOTAL
0					0.2				0.2
10				1.3	1.6	0.2			3.1
20				2.5	3.6				6.2
30			0.6	6.4	4.5				11.6
40			0.3	10.6	5.7				16.7
50				41.0	13.8				54.9
60			0.1	142.2	21.3				163.7
70				37.3	1.9				39.2
80			0.1	1.1					1.2
90									0.
100									0.
TOTAL	0.	0.	1.1	242.7	52.8	0.2	0.	0.	296.8

Rotor RPM — Temperature 0-20° F, Altitude 1000-1500 ft

Percent Torque	LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10									0.
20				0.4					0.4
30				1.1					1.1
40				1.4	1.5				2.9
50				11.3	4.3				15.6
60				9.6	3.3				12.9
70					0.1				0.1
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.	23.8	9.2	0.	0.	0.	33.0

Rotor RPM — Temperature 20-40° F, Altitude 1000-1500 ft.

Percent Torque	LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10				0.3	0.4				0.7
20			0.1	0.9	3.8				4.7
30			0.1	3.7	8.0	0.1			11.9
40			0.2	15.8	11.4				27.5
50			0.6	90.9	35.1				126.6
60			2.9	252.7	109.6				365.2
70			0.9	82.9	11.8				95.6
80				2.2	0.4				2.6
90									0.
100									0.
TOTAL	0.	0.	4.7	449.5	180.6	0.1	0.	0.	634.9

Table XIV (cont'd.)

Temperature 40-60° F
Altitude 1000-1500 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0				0.2	0.8	0.3			1.3
10				1.6	2.8	0.1	0.0		4.5
20				2.1	9.0				11.1
30		0.1	0.5	14.4	18.5				33.5
40		0.5	2.9	41.3	49.9				94.6
50			1.8	143.2	48.1				193.1
60			4.3	461.4	77.3				543.1
70			2.6	78.0	5.1				85.7
80			0.3	4.2					4.5
90									0.
100									0.
TOTAL	0.	0.6	12.4	746.5	211.6	0.4	0.0	0.	971.6

Temperature 60-80° F
Altitude 1000-1500 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10					0.9				0.9
20				0.6	1.9				2.5
30			1.2	4.8	5.2				11.2
40		0.1	1.0	13.4	20.2				40.6
50		0.1	0.4	66.3	36.8				103.6
60			0.1	276.0	126.0				402.1
70				43.6	5.1				48.7
80				0.2					0.2
90									0.
100									0.
TOTAL	0.	0.1	2.6	411.1	196.2	0.	0.	0.	610.0

Temperature 80-100° F
Altitude 1000-1500 ft

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0				0.1	0.1				0.1
10				0.1	0.2				0.3
20				1.1	0.6				1.6
30			0.4	3.1	0.3				3.8
40				3.9	2.3				6.2
50		0.2		14.6	5.9				20.7
60			0.4	62.5	27.1				90.0
70				10.1	0.9				11.0
80									0.
90									0.
100									0.
TOTAL	0.	0.2	0.8	95.4	37.4	0.	0.	0.	133.8

Temperature 0-20° F
Altitude 1500-2000 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10									0.
20									0.
30									0.
40				0.8					0.8
50					0.1				0.1
60									0.
70					0.2				0.2
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.	0.8	0.3	0.	0.	0.	1.1

Table XIV (cont'd.)

Temperature 20-40° F
Altitude 1500-2000 ft.

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0					0.3				0.3
10									0.
20				0.1					0.1
30				0.2	1.6	0.2			2.0
40			0.2	6.3	3.6	0.4			10.6
50			0.5	40.4	13.7				54.6
60				64.8	22.4				87.2
70				16.1	0.5				16.6
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.7	127.9	42.2	0.6	0.	0.	171.4

Temperature 40-60° F
Altitude 1500-2000 ft.

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0					0.2	0.6			0.8
10				0.8	0.9	0.3			2.0
20				1.1	2.6				3.7
30				4.9	5.3				10.2
40			0.1	15.1	12.4				27.6
50			0.7	36.4	25.6				62.8
60			3.1	70.9	27.7				101.7
70			1.7	17.1	1.4				20.2
80				2.5	0.2				2.7
90									0.
100									0.
TOTAL	0.	0.	5.6	148.8	76.4	0.9	0.	0.	231.7

Temperature 60-80° F
Altitude 1500-2000 ft.

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10					0.1				0.1
20					1.2				1.2
30			0.2	0.5	0.9				1.7
40		0.1	0.3	5.3	11.2				17.0
50				16.4	13.7				30.2
60			0.1	45.0	19.8				65.0
70				4.6	1.0				5.6
80									0.
90									0.
100									0.
TOTAL	0.	0.1	0.6	72.0	48.1	0.	0.	0.	120.8

Temperature 80-100° F
Altitude 1500-2000 ft.

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0					0.1	0.1	0.1		0.3
10									0.
20					0.2				0.2
30				0.7	0.1				0.8
40				3.3	0.6				3.9
50			0.5	2.5	0.8				3.8
60				7.4	2.8				10.2
70									0.
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.5	13.9	4.6	0.1	0.1	0.	19.2

Table XIV (cont'd.)

Temperature 0-20° F
Altitude 2000-2500 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10									0.
20									0.
30									0.
40				0.6	0.1				0.7
50				0.1					0.1
60									0.
70					0.2				0.2
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.	0.7	0.3	0.	0.	0.	1.0

Temperature 20-40° F
Altitude 2000-2500 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0					0.3				0.3
10									0.
20									0.
30									0.
40				1.4	0.9				2.3
50			0.3	8.7	2.0				11.0
60		0.1		0.8	0.9				1.8
70				0.4					0.4
80									0.
90									0.
100									0.
TOTAL	0.	0.1	0.3	11.3	4.1	0.	0.	0.	15.8

Temperature 40-60° F
Altitude 2000-2500 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0					0.7	0.1			0.8
10			0.1	0.5	1.1				1.7
20				0.8	1.0				1.8
30			0.1	1.4	1.9				3.4
40			1.8	10.7	5.2				17.6
50			0.4	28.6	18.7				47.7
60			0.1	29.1	17.8				47.0
70				5.0	0.9				6.0
80				0.6	0.2				0.8
90									0.
100									0.
TOTAL	0.	0.	2.5	76.7	47.4	0.1	0.	0.	126.8

Temperature 60-80° F
Altitude 2000-2500 ft

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10									0.
20									0.
30					0.6				0.6
40					0.1				0.1
50					0.3				0.3
60				1.6	3.9				5.5
70					0.3				0.3
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.	1.6	5.2	[illegible]	0.	0.	6.8

Table XIV (cont'd.)

Temperature 80-100° F
Altitude 2000-2500 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0					0.0	0.1			0.1
10				0.0	0.1				0.1
20					0.1				0.1
30				0.1					0.1
40				0.9					0.9
50			0.7	1.2	1.4				3.3
60				1.8	1.3				3.1
70									0.
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.7	4.0	2.9	0.1	0.	0.	7.8

Temperature 0-20°F
Altitude 2500-3000 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10									0.
20									0.
30					0.4				0.4
40				2.5	0.5	0.1			3.1
50			1.8	0.2	0.1				2.1
60					0.3				0.3
70									0.
80									0.
90									0.
100									0.
TOTAL	0.	0.	1.8	2.7	1.3	0.1	0.	0.	5.9

Temperature 20-40°F
Altitude 2500-3000 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0					0.6				0.6
10				0.2	0.8				1.0
20				0.4	0.5				0.9
30		0.2	0.8	0.8	0.7				2.6
40				0.1					0.1
50				0.0					0.0
60				0.1					0.1
70				0.7					0.7
80									0.
90									0.
100									0.
TOTAL	0.	0.2	0.8	2.5	2.6	0.	0.	0.	6.1

Temperature 40-60°F
Altitude 2500-3000 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0					0.1	0.2	0.0		0.3
10			0.1	0.8	0.4				1.3
20				1.2	3.0				4.1
30			0.0	4.8	8.9				13.8
40			5.4	5.9	8.9				20.2
50			1.2	5.3	5.9				12.4
60				8.8	1.9				10.8
70				10.0	0.6				10.6
80				0.6	0.1				0.7
90									0.
100									0.
TOTAL	0.	0.	6.8	37.5	29.9	0.2	0.0	0.	74.4

Table XV

Flight Time (Minutes) Spent in Torque Ranges versus Rotor RPM by Altitude Ranges

Altitude 0-500 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0				3.3	21.7	3.1	0.8	0.2	29.1
10		0.2	0.2	62.5	169.4	3.2	0.1	0.1	235.7
20		0.1	2.7	280.1	307.3	2.8			593.0
30		1.4	5.0	403.5	238.4	3.2	0.4		652.0
40	0.1	17.4	13.0	495.6	215.5	7.3			749.0
50	0.5	1.4	13.2	650.8	240.7	9.3	0.1		916.0
60		0.7	8.7	1173.8	255.3	3.4			1442.0
70		0.1	10.5	757.2	97.6	0.8			866.3
80		0.0	4.0	117.7	7.1				128.9
90			0.2	2.8	0.1				3.1
100									0.
TOTAL	0.6	21.3	57.7	3947.5	1553.3	33.2	1.4	0.2	5615.4

Altitude 500-1000 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0				0.7	3.6	1.0	0.1	0.0	5.5
10				8.2	23.2	1.3			32.7
20			0.1	41.8	62.4				104.3
30			3.5	99.7	86.5	0.9			190.7
40		0.4	11.9	282.0	143.6	0.5			438.5
50		0.5	3.0	824.2	346.3	1.3			1175.4
60			8.8	2711.8	653.8	0.2			3374.6
70			8.4	602.7	110.0				721.1
80			0.7	23.5	2.9				27.2
90				0.2					0.2
100									0.
TOTAL	0.	0.9	36.5	4595.1	1432.5	5.1	0.1	0.0	6070.4

Altitude 1000-1500 ft.

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0				0.2	0.9	0.3			1.4
10				2.0	4.3	0.1	0.0		6.4
20			0.1	5.1	15.2				20.3
30		0.1	2.1	27.2	32.1	0.1			61.6
40		0.6	4.1	81.8	85.5				171.9
50		0.3	2.8	326.4	130.2				459.7
60			7.7	1062.3	343.4				1413.4
70			3.5	214.7	23.0				241.2
80			0.3	6.6	0.4				7.3
90									0.
100									0.
TOTAL	0.	0.9	20.5	1726.4	635.0	0.4	0.0	0.	2383.4

Table XV (cont'd.)

Percent Torque				Rotor RPM			Altitude 1500-2000 ft.		
	LESS	231	242	253	264	275	286	297	TOTAL
0					0.6	0.7	0.1		1.4
10				0.8	1.1	0.3			2.2
20				1.2	3.9				5.1
30			0.2	6.4	7.9	0.2			14.7
40		0.1	0.6	30.8	27.9	0.4			59.7
50			1.7	95.8	54.0				151.5
60			3.2	188.1	72.8				264.1
70			1.7	37.9	3.1				42.7
80				2.5	0.2				2.7
90									0.
100									0.
TOTAL	0.	0.1	7.4	363.5	171.6	1.6	0.1	0.	544.3

Percent Torque				Rotor RPM			Altitude 2000-2500 ft		
	LESS	231	242	253	264	275	286	297	TOTAL
0					1.0	0.2			1.3
10			0.1	0.6	1.2				1.9
20				0.8	1.1				1.9
30			0.1	1.5	2.5				4.1
40			1.8	13.6	6.2				21.6
50			1.4	38.6	22.4				62.4
60		0.1	0.1	33.3	23.9				57.4
70				5.4	1.4				6.8
80				0.6	0.2				0.8
90									0.
100									0.
TOTAL	0.	0.1	3.5	94.4	59.9	0.2	0.	0.	158.2

Percent Torque				Rotor RPM			Altitude 2500-3000 ft		
	LESS	231	242	253	264	275	286	297	TOTAL
0					0.7	0.2	0.0		0.9
10			0.1	1.0	1.2				2.3
20				1.6	3.4				5.0
30		0.2	0.9	5.6	10.0				16.8
40			5.4	8.5	9.4	0.1			23.5
50			3.0	5.5	6.0				14.6
60				9.0	2.2				11.2
70				10.7	0.6				11.3
80				0.6	0.1				0.7
90									0.
100									0.
TOTAL	0.	0.2	9.4	42.6	33.8	0.3	0.0	0.	86.4

Table XVI

Flight Time (Minutes) Spent in Torque Ranges versus Rotor RPM by Airspeed Ranges and Mission Segments

Airspeed 0-40 Knots
Mission Segment Ascent

Percent Torque	LESS	231	242	253	264	275	286	297	TOTAL
				Rotor RPM					
0									0.
10				0.8	0.5				1.2
20			0.1	13.1	6.1	0.5			19.9
30			0.3	35.2	8.4	0.8			44.7
40		0.1	1.8	45.3	11.0	3.5			61.6
50	0.1		1.4	57.7	18.8	4.7			82.7
60			2.2	65.7	11.6	1.7			81.3
70			1.8	55.6	4.3	0.2			62.0
80		0.0	0.7	14.2	1.1				16.1
90				0.1					0.1
100									0.
TOTAL	0.1	0.2	8.5	287.9	61.8	11.3	0.	0.	369.9

Airspeed 40-60 Knots
Mission Segment Ascent

Percent Torque	LESS	231	242	253	264	275	286	297	TOTAL
				Rotor RPM					
0									0.
10									0.
20					0.1				0.1
30				0.2	0.2				0.4
40	0.1	0.3	0.2	2.1	0.7	0.1			3.5
50	0.1	0.2	0.5	8.0	3.1				12.0
60		0.0	0.6	34.9	7.2	0.4			43.1
70		0.1	1.9	82.1	7.0	0.2			91.3
80			1.5	21.4	1.5				24.4
90			0.1	0.7	0.1				0.9
100									0.
TOTAL	0.2	0.7	4.8	149.5	19.9	0.7	0.	0.	175.7

Airspeed 60-80 Knots
Mission Segment Ascent

Percent Torque	LESS	231	242	253	264	275	286	297	TOTAL
				Rotor RPM					
0									0.
10					0.2				0.2
20				0.1	0.0				0.2
30		0.2	0.4	1.5	1.0				3.2
40			0.1	3.6	3.1				6.8
50		0.1	0.8	12.9	7.2	0.2			21.1
60			1.0	73.8	17.3	0.6			92.9
70			3.6	189.8	21.1	0.5			215.0
80			1.4	43.5	2.7				47.6
90				1.1					1.1
100									0.
TOTAL	0.	0.4	7.3	326.4	52.7	1.4	0.	0.	388.2

Airspeed 80-100 Knots
Mission Segment Ascent

Percent Torque	LESS	231	242	253	264	275	286	297	TOTAL
				Rotor RPM					
0									0.
10					0.1				0.1
20					0.3				0.3
30			0.5	2.2	0.8				3.5
40			1.2	6.7	3.4	0.1			11.5
50		0.3	1.1	19.6	11.7		0.1		32.8
60			1.4	182.7	41.3	0.4			225.8
70			3.3	317.8	48.8				370.0
80			0.2	41.6	3.4				45.2
90			0.1	0.4	0.0				0.6
100									0.
TOTAL	0.	0.3	7.8	571.1	109.9	0.5	0.1	0.	689.7

Table XVI (cont'd.)

Airspeed 100-120 Knots
Mission Segment Ascent

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10									0.
20					0.1				0.1
30				0.4	0.6				1.0
40			0.3	4.9	1.9				7.1
50			0.3	23.0	11.4				34.8
60			1.5	239.6	64.5				305.6
70			2.2	210.6	38.6				251.5
80				16.5	1.2				17.7
90				0.2					0.2
100									0.
TOTAL	0.	0.	4.4	495.3	118.4	0.	0.	0.	618.1

Airspeed 120-140 Knots
Mission Segment Ascent

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10									0.
20									0.
30					0.3				0.3
40				0.2	0.3				0.5
50			0.3	3.2	2.4				5.8
60			0.3	53.5	21.0				74.8
70			1.2	37.0	5.7				44.0
80			0.3	1.9					2.2
90									0.
100									0.
TOTAL	0.	0.	2.1	95.8	29.7	0.	0.	0.	127.6

Airspeed 0-40 Knots
Mission Segment Cruise

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10					0.0				0.0
20				0.0	0.2				0.3
30				0.7	0.7				1.4
40				1.3	2.2	0.1			3.6
50				0.8	1.1				1.9
60				0.7	0.6				1.3
70				0.1					0.1
80				0.0					0.0
90									0.
100									0.
TOTAL	0.	0.	0.	3.6	4.9	0.1	0.	0.	8.6

Airspeed 40-60 Knots
Mission Segment Cruise

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0					0.1				0.1
10					0.2				0.2
20				0.1	0.6	0.0			0.8
30				1.8	4.2				6.0
40		0.4	0.3	2.9	4.0				7.6
50				2.0	1.2				3.2
60			0.2	0.1	0.3				0.7
70			0.1	1.4					1.4
80									0.
90									0.
100									0.
TOTAL	0.	0.4	0.6	8.2	10.7	0.0	0.	0.	19.9

Table XVI (cont'd.)

Airspeed 60-80 Knots
Mission Segment Cruise

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0						0.0			0.0
10				0.1	1.0				1.1
20			0.1	0.3	4.0	0.2			4.6
30			0.3	11.4	15.0				26.7
40		0.1	1.8	27.9	35.5	0.1			65.4
50			1.0	16.8	5.8	0.1			23.7
60			0.2	9.7	2.6				12.5
70			0.1	11.9	0.6				12.6
80				1.0					1.0
90				0.1					0.1
100									0.
TOTAL	0.	0.1	3.4	79.3	64.5	0.5	0.	0.	147.8

Airspeed 80-100 Knots
Mission Segment Cruise

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10					0.6	0.0			0.7
20				0.9	4.4	0.2			5.5
30		0.1	3.9	23.5	24.0	0.8			52.3
40		0.4	10.8	99.3	54.7	0.2			165.4
50		0.2	2.6	46.1	24.7	0.1			73.8
60		0.1	0.2	84.2	11.0				95.5
70			0.3	57.7	2.1				60.1
80				1.8	0.3				2.1
90									0.
100									0.
TOTAL	0.	0.9	17.9	313.5	121.9	1.4	0.	0.	455.6

Airspeed 100-120 Knots
Mission Segment Cruise

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10					0.4				0.4
20			0.1	0.1	3.0				3.2
30			2.1	18.6	19.1	0.3			40.1
40		1.0	11.0	143.4	78.8	0.2			234.4
50		0.2	5.4	445.5	200.4				651.6
60			3.7	1010.0	212.9				1226.6
70			0.5	194.1	22.8				217.4
80				3.4	0.6				4.0
90				0.2					0.2
100									0.
TOTAL	0.	1.2	22.8	1815.4	538.1	0.5	0.	0.	2378.1

Airspeed 120-140 Knots
Mission Segment Cruise

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10									0.
20					0.2				0.2
30			0.3	1.2	1.5				3.0
40		0.2	0.1	45.3	20.5				66.1
50			0.6	750.6	271.0				1022.3
60			12.4	3132.4	900.1				4044.9
70			7.4	435.9	80.8				524.1
80			0.6	4.5					5.1
90									0.
100									0.
TOTAL	0.	0.2	21.4	4369.9	1274.2	0.	0.	0.	5665.7

Table XVI (cont'd.)

Airspeed 140-160 Knots
Mission Segment Cruise

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10									0.
20									0.
30									0.
40									0.
50									0.
60			0.2	8.8					9.0
70				3.6	0.6				4.2
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.2	12.4	0.6	0.	0.	0.	13.2

Airspeed 0-40 Knots
Mission Segment Descent

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0						0.2			0.2
10				0.8	0.9				1.7
20				5.2	5.2				10.4
30			0.0	12.0	8.0	0.5	0.4		21.0
40		0.1	0.4	5.5	5.5	0.3			11.8
50			0.6	2.1	0.8	0.6			4.1
60			0.1	0.2	0.8	0.2			1.3
70				0.0					0.0
80									0.
90									0.
100									0.
TOTAL	0.	0.1	1.2	25.9	21.3	1.9	0.4	0.	50.6

Airspeed 40-60 Knots
Mission Segment Descent

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0				0.6	2.7	0.8	0.2		4.3
10				11.0	25.8	0.7			37.4
20			0.6	54.6	41.0	0.1			96.4
30			0.4	44.0	18.1	0.2			62.8
40			0.1	10.6	3.0				13.8
50			0.2	1.3					1.5
60				0.2	0.1				0.3
70				0.1					0.1
80									0.
90									0.
100									0.
TOTAL	0.	0.	1.3	122.6	90.7	1.8	0.2	0.	216.7

Airspeed 60-80 Knots
Mission Segment Descent

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0				2.1	12.6	2.0	0.5	0.2	17.4
10			0.2	30.6	77.5	1.5	0.0	0.1	109.9
20			0.3	84.9	97.1	0.6			182.9
30			0.6	48.7	33.4	0.2			82.9
40			0.1	17.5	3.5				21.1
50			0.1	2.6					2.6
60			0.1	0.1					0.2
70									0.
80									0.
90									0.
100									0.
TOTAL	0.	0.	1.3	186.6	224.1	4.3	0.6	0.2	417.2

Table XVI (cont'd.)

Airspeed 80-100 Knots
Mission Segment Descent

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0				1.0	9.8	1.9	0.3		12.9
10				18.2	60.0	2.0	0.1		80.4
20				68.9	118.2	0.1			187.3
30			0.1	67.4	57.7				125.3
40			0.7	24.5	12.3	0.2			37.7
50				7.6	2.7				10.3
60				1.3	0.4				1.7
70				0.3	0.1				0.4
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.8	189.4	261.3	4.2	0.4	0.	456.1

Airspeed 100-120 Knots
Mission Segment Descent

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0					2.2	0.6			2.8
10				4.6	21.1	0.6			26.3
20			0.1	38.3	71.0				109.4
30			0.4	113.6	115.7				229.7
40			0.9	159.8	106.7	0.2			267.6
50			1.4	100.7	55.0				157.1
60			0.2	19.1	4.5				23.7
70			0.2	1.2	0.2				1.6
80									0.
90									0.
100									0.
TOTAL	0.	0.	3.1	437.4	376.4	1.4	0.	0.	818.4

Airspeed 120-140 Knots
Mission Segment Descent

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0					0.2				0.2
10				0.2	1.3				1.5
20				2.2	5.4				7.6
30			0.1	19.6	22.1				41.8
40			0.5	97.0	69.9	0.1			167.5
50			0.7	275.5	124.2				400.4
60			0.2	193.3	47.5				241.0
70			0.4	14.1	2.8				17.2
80									0.
90									0.
100									0.
TOTAL	0.	0.	1.9	601.9	273.4	0.1	0.	0.	877.4

Airspeed 140-160 Knots
Mission Segment Descent

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10									0.
20									0.
30				0.1					0.1
40				0.1					0.1
50				0.6	0.1				0.7
60				1.3	0.1				1.4
70				0.1					0.1
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.	2.2	0.1	0.	0.	0.	2.3

Table XVI (cont'd.)

Airspeed 0-40 Knots
Mission Segment Flare and Landing

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0				0.1	0.1	0.0			0.2
10				1.5	2.3				3.8
20			0.6	23.5	11.6				35.7
30		0.3	1.7	104.0	26.5				132.6
40		0.4	3.8	146.7	32.0	0.2			183.0
50		0.1	5.0	129.8	11.9				146.9
60			3.7	62.9	2.9				69.5
70			1.2	14.7	0.1				16.0
80			0.3	1.6					2.0
90				0.0					0.0
100									0.
TOTAL	0.	0.8	16.3	484.9	87.5	0.2	0.	0.	589.8

Airspeed 40-60 Knots
Mission Segment Flare and Landing

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0				0.4	0.7			0.1	1.1
10				5.6	6.6				12.2
20			0.1	26.3	11.1				37.6
30			0.2	23.4	3.9				27.4
40			0.2	3.5	0.3				4.0
50				0.2					0.2
60			0.1	0.1					0.1
70									0.
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.5	59.5	22.6	0.	0.	0.1	82.7

Airspeed 60-80 Knots
Mission Segment Flare and Landing

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0				0.1	0.3				0.4
10				1.3	1.5				2.8
20				3.9	1.7				5.6
30				1.2					1.2
40				0.1					0.1
50				0.2					0.2
60									0.
70									0.
80									0.
90									0.
100									0.
TOTAL	0.	0.	0.	6.9	3.4	0.	0.	0.	10.3

Airspeed 0-40 Knots
Mission Segment Hover

Percent Torque	Rotor RPM								
	LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10		0.2	0.2	0.3	0.4				1.1
20		0.1	0.9	7.8	11.7	1.0			21.5
30		1.1	0.4	13.2	16.0	1.6			32.4
40		15.6	2.4	64.0	38.7	3.0			123.8
50	0.3	0.9	3.3	34.5	46.2	4.8			89.9
60		0.7	0.2	3.5	4.6	0.3			9.3
70				0.2					0.2
80									0.
90									0.
100									0.
TOTAL	0.3	18.6	7.4	123.4	117.7	10.6	0.	0.	278.1

Table XVII

Flight Time (Minutes) Spent in Torque Ranges versus Rotor RPM by Mission Segment

Mission Segment Ascent

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10				0.8	0.7				1.5
20			0.1	13.3	6.7	0.5			20.6
30		0.2	1.2	39.4	11.3	0.8			53.0
40	0.1	0.4	3.5	62.8	20.5	3.7			91.0
50	0.2	0.7	4.4	124.4	54.6	4.9	0.1		189.3
60		0.0	7.1	650.4	162.9	3.1			823.6
70		0.1	14.1	693.1	125.6	0.8			1033.8
80		0.0	4.1	139.1	10.0				153.3
90			0.2	2.7	0.1				3.0
100									0.
TOTAL	0.3	1.5	34.8	1926.1	392.6	13.8	0.1	0.	2369.3

Mission Segment Cruise

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0					0.1	0.0			0.1
10				0.1	2.3	0.0			2.5
20			0.2	1.4	12.4	0.5			14.5
30		0.1	6.6	57.1	64.5	1.2			129.5
40		2.0	24.1	320.2	195.7	0.6			542.6
50		0.4	9.6	1261.8	504.3	0.2			1776.4
60		0.1	16.9	4245.9	1127.7				5390.6
70			8.3	704.7	106.9				420.0
80			0.6	10.7	0.9				12.3
90				0.4					0.4
100									0.
TOTAL	0.	2.7	66.3	6602.4	2015.0	2.6	0.	0.	8699.9

Mission Segment Descent

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0				3.7	27.4	5.4	1.1	0.2	37.8
10			0.2	65.5	186.6	4.8	0.2	0.1	257.4
20			1.0	254.3	338.0	0.8			594.1
30			1.7	305.5	255.1	0.9	0.4		563.6
40		0.1	2.8	315.0	201.0	0.8			519.7
50			2.9	390.4	182.7	0.6			576.7
60			0.5	215.6	53.4	0.2			269.7
70			0.6	15.9	3.0				19.6
80									0.
90									0.
100									0.
TOTAL	0.	0.1	9.6	1566.1	1247.4	13.6	1.7	0.2	2638.8

Table XVII (cont'd.)

Mission Segment Flare and Landing

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0				0.5	1.1	0.0		0.1	1.7
10				8.4	10.4				18.8
20			0.7	53.7	24.4				78.9
30		0.3	1.9	123.7	30.4				161.3
40		0.4	4.0	150.3	32.3	0.2			187.2
50		0.1	5.0	130.2	11.9				147.3
60			3.8	62.9	2.9				69.6
70			1.2	14.7	0.1				16.0
80			0.3	1.6					2.0
90				0.0					0.0
100									0.
TOTAL	0.	0.8	16.9	551.3	113.5	0.2	0.	0.1	682.9

Mission Segment Hover

Percent Torque	Rotor RPM LESS	231	242	253	264	275	286	297	TOTAL
0									0.
10		0.2	0.2	0.3	0.4				1.1
20		0.1	0.9	7.8	11.7	1.0			21.5
30		1.1	0.4	13.2	16.0	1.6			32.4
40		15.6	2.4	64.0	38.7	3.0			123.6
50	0.3	0.9	3.3	34.5	46.2	4.9			89.9
60		0.7	0.2	3.5	4.6	0.3			9.3
70				0.2					0.2
80									0.
90									0.
100									0.
TOTAL	0.3	18.6	7.4	123.5	117.7	10.6	0.	0.	278.2

Table XVIII

Flight Time (Minutes) Spent in Altitude Ranges versus Tip Speed Ratio, μ, by Gross Weight Ranges

Altitude Feet	Tip Speed Ratio, μ								Gross Weight 12,000 to 13,000 lb	
	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS	2.8	181.9	108.9	59.0	94.2	100.8	105.2	75.0	0.1	728.1
500	0.1	11.4	4.3	6.0	24.4	109.6	231.3	216.1	0.1	603.5
1000		0.4	0.8	1.0	22.3	56.4	116.5	99.5	1.3	298.3
1500		0.2	0.3	1.2	9.0	19.6	47.9	49.5		127.7
2000		0.3	0.1	0.1	3.2	17.9	44.0	24.0		89.7
2500				0.6	5.5	21.5	27.8	11.9		67.4
TOTAL	2.9	194.2	114.4	68.0	158.8	326.0	572.8	476.1	1.5	1914.9

Altitude Feet	Tip Speed Ratio, μ								Gross Weight 13,000 to 14,000 lb	
	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS	1.1	99.2	72.9	57.7	85.2	111.5	141.4	148.4	0.6	718.1
500		0.2	2.6	6.6	25.2	91.1	302.8	451.2		879.9
1000		0.5	1.6	2.1	9.6	29.7	119.2	249.3	0.1	412.2
1500			0.2	0.5	3.0	3.9	22.7	32.9		63.2
2000			0.4		0.6	2.2	7.0	3.0		13.2
2500			0.4	0.4	0.9	14.7	10.7	0.1		27.2
TOTAL	1.1	99.9	78.1	67.4	124.6	253.1	604.0	884.9	0.7	2113.9

Altitude Feet	Tip Speed Ratio, μ								Gross Weight 14,000 to 15,000 lb	
	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS	0.4	134.7	133.6	109.5	166.5	189.1	265.1	271.2		1270.3
500		1.2	2.8	6.4	35.9	107.8	466.5	916.5		1537.2
1000		5.0	3.7	3.6	12.1	38.7	221.0	365.4		649.5
1500				2.4	5.8	15.3	100.0	71.5		195.0
2000					0.2	1.1	20.3	9.0		30.6
2500						0.5	1.9			2.4
TOTAL	0.4	140.9	140.2	121.9	220.5	352.5	1074.8	1633.7	0.	3685.2

Altitude Feet	Tip Speed Ratio, μ								Gross Weight 15,000 to 16,000 lb	
	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS	0.5	126.6	120.5	117.5	166.7	215.0	267.5	273.1	0.9	1288.5
500		7.6	4.5	9.9	23.7	93.7	472.7	911.0	1.3	1524.4
1000		1.3	3.2	5.0	7.4	26.6	198.1	358.2	0.8	600.7
1500			0.2	1.7	2.8	9.6	71.1	48.1		133.5
2000			0.4	0.3		0.2	16.8	4.9		22.6
2500										0.
TOTAL	0.5	135.5	128.8	134.4	200.6	345.1	1026.2	1595.4	3.0	3569.7

Altitude Feet	Tip Speed Ratio, μ								Gross Weight 16,000 to 17,000 lb	
	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS	1.1	169.2	130.5	119.2	195.0	211.2	210.4	180.1	0.2	1217.1
500		1.4	3.9	6.5	34.8	99.0	460.6	642.2	4.2	1252.7
1000		0.3	2.9	5.1	29.0	30.3	155.6	257.3		480.6
1500			0.1	0.5	1.1	5.3	37.3	45.1	0.4	89.9
2000				0.2		0.6	17.8	1.8		20.4
2500					0.4	2.6	2.9			5.9
TOTAL	1.1	170.9	147.4	131.5	260.3	349.2	884.7	1126.6	4.8	3066.7

Table XVIII (cont'd.)

Altitude Feet	Tip Speed Ratio, μ								Gross Weight 17,000 to 18,000 lb	
	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS	1.0	99.4	102.7	105.3	191.5	190.3	203.6	142.1	0.3	1036.5
500		0.2	0.6	3.8	30.7	129.8	513.2	605.4	1.2	1285.0
1000				0.3	2.3	30.9	262.7	284.3		580.4
1500						4.1	75.9	39.1		119.1
2000						0.6	8.8	0.8		10.2
2500										0.
TOTAL	1.0	99.6	103.3	109.4	224.5	355.7	1064.2	1071.8	1.5	3031.3

Altitude Feet	Tip Speed Ratio, μ								Gross Weight 18,000 to 19,000 lb	
	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS	0.2	41.9	44.9	50.2	92.8	92.6	94.6	52.9		470.2
500		0.1	1.4	3.3	17.3	70.6	306.3	219.7		618.9
1000				0.9	2.4	16.3	214.0	163.7		397.4
1500					0.4	3.0	35.4	15.7		54.5
2000							17.5	1.3		18.8
2500										0.
TOTAL	0.2	42.0	46.3	54.4	112.9	182.6	667.9	453.4	0.	1559.9

Table XIX

Flight Time (Minutes) Spent in Altitude Ranges versus Tip Speed Ratio, μ

Altitude Feet	Tip Speed Ratio, μ									
	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS	7.3	853.0	714.1	618.6	992.1	1110.6	1288.0	1143.0	2.1	6729.0
500	0.1	22.2	20.2	42.6	192.1	701.8	2753.5	3962.3	6.8	7701.7
1000		7.5	12.2	18.0	85.2	229.0	1287.2	1777.8	2.2	3419.3
1500		0.2	0.8	6.3	22.1	60.8	390.4	302.0	0.4	783.0
2000		0.3	0.9	0.6	4.0	22.6	132.3	44.8		205.6
2500			0.4	1.0	6.8	39.4	43.3	12.0		102.9
TOTAL	7.4	883.2	748.6	687.1	1302.3	2164.3	5894.8	7242.0	11.5	18941.5

Table XX

Peak Delta n_z versus Tip Speed Ratio, μ, by Mission Segment

Tip Speed Ratio, μ — Mission Segment: Take-off and Ascent

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6					1		1	1		3
0.5			1			11	2	4		18
0.4					4	14	30	12		60
0.3		5	3	15	30	110	126	22		311
0.2		110	81	89	282	694	646	145		2047
-0.2										0
-0.3		13	5	26	130	364	572	89		1199
-0.4		3	2	5	17	64	91	24		206
-0.5		1			3	10	22	5		41
-0.6					1	2	4			7
-0.8					1		2			3
LESS										0
TOTAL	0	132	92	135	469	1269	1496	302	0	3895
MIN.	2.1	250.9	223.2	242.0	532.1	942.0	798.5	123.0	0.	3114.0

Tip Speed Ratio, μ — Mission Segment: Cruise

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0								1		1
0.9							1			1
0.8					1					1
0.7							2			2
0.6						2	14	8		24
0.5				1	1	9	29	28		68
0.4				1	8	32	138	195		374
0.3			1	5	68	133	802	1196	2	2207
0.2		2	4	23	205	558	4009	6898	4	11703
-0.2										0
-0.3			6	19	120	384	3670	5368	7	9574
-0.4		1		3	24	83	777	948		1836
-0.5					2	8	123	162		295
-0.6						3	23	18		44
-0.8						1	4	5		10
LESS										0
TOTAL	0	3	11	52	429	1213	9592	14827	13	26140
MIN.	0.	2.8	8.2	28.2	199.0	618.9	3903.1	6187.5	10.2	10958.1

Tip Speed Ratio, μ — Mission Segment: Descent

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8							1			1
0.7					1					1
0.6					1	4	2	3		10
0.5		1			5	6	8	4		24
0.4		2		4	16	22	37	25		106
0.3		3	1	40	73	88	213	157	1	576
0.2		10	23	202	466	564	1265	1000	1	3531
-0.2										0
-0.3		6	14	71	176	327	1011	836		2441
-0.4		4	1	8	29	57	178	129		406
-0.5				1	5	6	43	21		76
-0.6				1			10	8		19
-0.8							1			1
LESS										0
TOTAL	0	26	39	327	772	1074	2769	2183	2	7192
MIN.	0.	12.7	62.5	319.4	560.8	603.2	1193.0	931.4	1.3	3684.1

Table XX (cont'd.)

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	Mission Segment Flare and Landing TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4		1	1	1	1					4
0.3		2	9	7						18
0.2		51	103	54	4					212
-0.2										0
-0.3		31	23	3						57
-0.4		4	3							7
-0.5			1							1
-0.6										0
-0.8										0
LESS										0
TOTAL	0	89	140	65	5	0	0	0	0	299
MIN.	1.9	328.6	365.2	97.4	10.3	0.1	0.	0.	0.	803.3

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	Mission Segment Hover TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4		2								2
0.3			1							1
0.2		18	7							25
-0.2										0
-0.3		19	11							30
-0.4		9	7							16
-0.5		3								3
-0.6										0
-0.8										0
LESS										0
TOTAL	0	51	26	0	0	0	0	0	0	77
MIN.	3.4	288.4	89.4	0.0	0.	0.	0.	0.	0.	381.3

Table XXI

Peak Delta n_z versus Tip Speed Ratio, μ

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0								1		1
0.9							1			1
0.8					1		1			2
0.7					1		2			3
0.6					2	6	17	12		37
0.5		1	1	1	6	26	39	36		110
0.4		5	1	6	29	68	205	232		546
0.3		10	15	67	171	331	1141	1375	3	3113
0.2		191	218	369	957	1816	5920	8043	5	17518
-0.2										0
-0.3		69	59	113	426	1075	5253	6293	7	13301
-0.4		21	13	16	70	204	1046	1101		2471
-0.5		4	1	1	10	24	188	188		416
-0.6				1	1	5	37	26		70
-0.8					1	1	7	5		14
LESS										0
TOTAL	0	301	308	579	1675	3556	13857	17312	15	37603
MIN.	7.4	883.2	748.6	687.1	1302.3	2164.3	5894.7	7241.9	11.5	18941.2

Table XXII

Peak Delta n_z versus Airspeed by Mission Segment

Airspeed - Knots — Mission Segment: Take-off and Ascent

Delta n_z	LESS	40	60	80	100	120	140	TOTAL
1.4								0
1.2								0
1.0								0
0.9								0
0.8								0
0.7								0
0.6			1		1	1		3
0.5	1			11	2	4		18
0.4			4	14	26	16		60
0.3	8	14	29	101	128	31		311
0.2	190	84	256	671	644	202		2047
-0.2								0
-0.3	18	22	114	342	573	130		1199
-0.4	4	6	17	52	95	32		206
-0.5	1		3	9	20	8		41
-0.6			1	2	4			7
-0.8			1		2			3
LESS								0
TOTAL	222	126	426	1202	1495	424	0	0
MIN.	474.2	235.7	506.7	911.5	823.4	162.4	0.	3114.0

Airspeed - Knots — Mission Segment: Cruise

Delta n_z	LESS	40	60	80	100	120	140	TOTAL
1.4								0
1.2								0
1.0						1		1
0.9					1			1
0.8			1					1
0.7					2			2
0.6				1	13	10		24
0.5		1	1	5	26	35		68
0.4		1	6	31	110	226		374
0.3		4	64	111	642	1383	3	2207
0.2	5	20	183	483	3098	7900	14	11703
-0.2								0
-0.3	5	11	121	314	2752	6353	18	9574
-0.4	1	3	19	68	586	1159		1836
-0.5			2	5	87	201		295
-0.6				2	20	22		44
-0.8				1	3	6		10
LESS								0
TOTAL	11	40	397	1021	7340	17296	35	0
MIN.	10.3	23.8	183.0	554.0	3082.6	7091.0	13.2	10958.1

Airspeed - Knots — Mission Segment: Descent

Delta n_z	LESS	40	60	80	100	120	140	TOTAL
1.4								0
1.2								0
1.0								0
0.9								0
0.8					1			1
0.7			1					1
0.6			1	3	3	3		10
0.5	1		4	6	9	4		24
0.4	2	4	16	19	35	30		106
0.3	3	30	72	86	163	202		576
0.2	27	170	444	543	1119	1225	3	3531
-0.2								0
-0.3	19	61	156	293	849	1061		2441
-0.4	5	8	21	55	160	157		406
-0.5		1	5	6	35	29		76
-0.6			1		10	8		19
-0.8					1			1
LESS								0
TOTAL	57	274	723	1011	2405	2719	3	0
MIN.	69.3	248.3	535.7	576.8	1051.9	1159.5	2.3	3684.1

Table XXII (cont'd.)

Delta n_z	LESS	40	60	80	100	120	140	TOTAL
			Airspeed	Knots		Mission Segment Flare and Landing		
1.4								0
1.2								0
1.0								0
0.9								0
0.8								0
0.7								0
0.6								0
0.5								0
0.4	2	1	1					4
0.3	11	6	1					18
0.2	155	52	5					212
-0.2								0
-0.3	53	3	1					57
-0.4	7							7
-0.5	1							1
-0.6								0
-0.8								0
LESS								0
TOTAL	229	62	8	0	0	0	0	0
MIN.	691.4	100.4	11.9	0.1	0.	0.	0.	803.8

Delta n_z	LESS	40	60	80	100	120	140	TOTAL
			Airspeed	Knots			Mission Segment Hover	
1.4								0
1.2								0
1.0								0
0.9								0
0.8								0
0.7								0
0.6								0
0.5								0
0.4	2							2
0.3	1							1
0.2	25							25
-0.2								0
-0.3	30							30
-0.4	16							16
-0.5	3							3
-0.6								0
-0.8								0
LESS								0
TOTAL	77	0	0	0	0	0	0	0
MIN.	381.2	0.0	0.	0.	0.	0.	0.	381.3

Table XXIII

Peak Delta n_z versus Airspeed

Delta n_z	LESS	40	60	80	100	120	140	TOTAL
			Airspeed	Knots				
1.4								0
1.2								0
1.0						1		1
0.9					1			1
0.8			1		1			2
0.7			1		2			3
0.6			2	4	17	14		37
0.5	2	1	5	22	37	43		110
0.4	6	6	27	64	171	272		546
0.3	23	54	166	298	953	1616	3	3113
0.2	402	326	886	1697	4861	9327	17	17518
-0.2								0
-0.3	125	97	394	949	4174	7544	18	13301
-0.4	33	17	57	175	841	1348		2471
-0.5	5	1	10	20	142	238		416
-0.6			2	4	34	30		70
-0.8			1	1	6	6		14
LESS								0
TOTAL	596	502	1554	3234	11240	20439	38	0
MIN.	1626.5	649.3	1237.3	2042.5	4958.0	8413.0	15.5	18941.2

Table XXIV

Peak Delta n_z versus Tip Speed Ratio, μ, by Torque Ranges

Tip Speed Ratio, μ — Torque 0-10%

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6						1				1
0.5										0
0.4				3	1	3				7
0.3				2	5	3				10
0.2			4	4	17	12	6			43
-0.2										0
-0.3				2	9	6				17
-0.4					1	2				3
-0.5										0
-0.6										0
-0.8										0
LESS										0
TOTAL	0	0	4	11	33	27	6	0	0	81
MIN.	0.	0.	0.7	7.1	18.7	11.8	1.4	0.	0.	39.6

Tip Speed Ratio, μ — Torque 10-20%

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5						1				1
0.4					4		1			5
0.3				9	9	7	2			27
0.2		1	11	41	92	87	26	1		259
-0.2										0
-0.3			1	9	34	31	12			87
-0.4				1	6	3	2			12
-0.5							1			1
-0.6										0
-0.8										0
LESS										0
TOTAL	0	1	12	60	145	129	44	1	0	392
MIN.	0.	2.4	6.6	60.0	117.1	75.6	18.9	0.6	0.	281.2

Tip Speed Ratio, μ — Torque 20-30%

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6						1				1
0.5							1			1
0.4					6	4	2			12
0.3		1	2	9	15	25	21	1		74
0.2		7	22	71	147	158	114	4		523
-0.2										0
-0.3			4	16	52	85	64	5		226
-0.4		1			5	9	10			25
-0.5							2	1		3
-0.6										0
-0.8										0
LESS										0
TOTAL	0	9	28	96	225	282	214	11	0	865
MIN.	1.1	40.6	49.3	141.8	206.4	193.3	94.0	3.0	0.	729.7

Table XXIV (cont'd.)

Torque 30-40%

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6						1				1
0.5						3	2			5
0.4		1	1	1	3	2	8	1		17
0.3		1	1	10	28	29	39	9		117
0.2		19	37	61	137	166	236	29		735
-0.2										0
-0.3		6	7	20	53	120	176	19		401
-0.4		1	1	6	11	13	35	3		70
-0.5			1		1	5	5			12
-0.6						1	2			3
-0.8							1			1
LESS										0
TOTAL	0	28	48	98	233	340	554	61	0	1362
MIN.	1.3	118.0	114.7	100.2	119.3	199.6	262.0	24.6	0.1	939.9

Torque 40-50%

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9							1			1
0.8										0
0.7					1		1			2
0.6						2	3			5
0.5		1		1	3	5	6	1		17
0.4		3		1	5	16	18	5		48
0.3		3	3	5	30	55	131	39	1	267
0.2		34	27	26	97	246	678	224		1332
-0.2										0
-0.3		17	16	18	58	138	475	136		858
-0.4		8	2	2	12	43	91	33		191
-0.5		1			1	4	21	7		34
-0.6							5	1		6
-0.8										0
LESS										0
TOTAL	0	67	48	53	207	509	1430	446	1	2761
MIN.	1.7	217.9	164.[illegible]	29.9	101.4	232.3	556.6	159.6	0.1	1464.3

Torque 50-60%

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8							1			1
0.7							1			1
0.6					1		7	3		11
0.5					2	3	8	10		23
0.4		1		1	2	14	65	51		134
0.3		4	2	3	17	52	343	313		734
0.2		47	28	19	53	166	1560	1586	1	3460
-0.2										0
-0.3		15	10	7	39	122	1202	1126		2521
-0.4		4	3		7	24	247	207		492
-0.5		1				3	46	27		77
-0.6						1	10	6		17
-0.8						1		1		2
LESS										0
TOTAL	0	72	43	30	121	386	3490	3330	1	7473
MIN.	2.0	208.1	116.1	17.9	49.7	132.5	1092.7	1160.4	0.2	2779.8

Table XXIV (cont'd.)

Torque 60-70%

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
					Tip Speed Ratio, μ					
1.4										0
1.2										0
1.0										0
0.9										0
0.8					1					1
0.7										0
0.6							2	4		6
0.5						4	10	19		33
0.4					1	7	51	107		166
0.3			2	4	15	44	301	639		1005
0.2		24	22	19	66	264	1601	4018		6014
-0.2										0
-0.3		5	4	5	37	144	1580	2987	1	4763
-0.4		2	4	1	3	27	317	492		846
-0.5						3	49	88		140
-0.6					1	2	12	11		26
-0.8							4	3		7
LESS										0
TOTAL	0	31	32	29	124	495	3927	8368	1	13007
MIN.	0.7	86.7	75.5	45.5	112.5	348.7	1967.0	3919.3	6.7	6562.8

Torque 70-80%

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
					Tip Speed Ratio, μ					
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6								3		3
0.5						2	4	4		10
0.4					1	4	16	16		37
0.3			2	1	14	37	69	88	2	213
0.2		13	14	34	111	290	403	484	4	1353
-0.2										0
-0.3		1	1	6	38	145	365	411	6	973
-0.4		2		3	2	10	56	78		151
-0.5					1	2	10	7		20
-0.6						1	1	1		3
-0.8					1					1
LESS										0
TOTAL	0	16	17	44	168	491	924	1092	12	2764
MIN.	0.2	30.2	48.5	94.3	238.8	442.3	488.9	541.8	4.4	1889.6

Torque 80-90%

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
					Tip Speed Ratio, μ					
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5			1				1			2
0.4							1			1
0.3				2	2	7	2	1		14
0.2		8	5	7	29	44	22	13		128
-0.2										0
-0.3				1	8	15	18	12		54
-0.4					2	9	5	4		20
-0.5								1		1
-0.6										0
-0.8										0
LESS										0
TOTAL	0	8	6	10	41	75	49	31	0	220
MIN.	0.1	5.8	12.4	24.4	50.7	46.5	20.1	7.4	0.	167.6

Table XXIV (cont'd.)

Torque 90-100%

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4										0
0.3										0
0.2					2	2	2			6
-0.2										0
-0.3							1			1
-0.4					1					1
-0.5							2			2
-0.6										0
-0.8										0
LESS										0
TOTAL	0	0	0	0	3	2	5	0	0	10
MIN.	0.	0.	0.2	1.0	1.2	0.6	0.4	0.	0.	3.4

Table XXV

Peak Delta n_z versus Tip Speed Ratio, μ, by Altitude Ranges and Gross Weight Ranges

Gross Weight 12,000 to 13,000 lb
Altitude 0-500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6						1	1			2
0.5				1	1	1	1	3		7
0.4		2	1	2	8	13	8	9		43
0.3		1	5	15	28	40	39	37	1	166
0.2		34	50	61	111	149	154	159		718
-0.2										0
-0.3		11	12	23	69	73	100	108		396
-0.4		4	3	3	15	18	15	23		81
-0.5		1			1	2	3	11		18
-0.6							1	1		2
-0.8							1			1
LESS										0
TOTAL	0	53	71	105	233	297	323	351	1	1434
MIN.	2.8	161.9	108.9	59.0	94.2	100.8	105.2	75.0	0.1	728.1

Gross Weight 13,000 to 14,000 lb
Altitude 0-500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6					1					1
0.5					3	2				5
0.4					1	7	4	5		17
0.3		5	3	2	12	15	18	23		78
0.2		40	28	28	65	103	137	169		570
-0.2										0
-0.3		7	8	2	34	34	81	105		271
-0.4				2	5	4	16	9		36
-0.5					1		1	3		5
-0.6								1		1
-0.8					1		1			2
LESS										0
TOTAL	0	52	39	34	123	165	258	315	0	986
MIN.	1.1	99.2	72.9	57.7	85.2	111.5	141.4	148.4	0.6	718.1

Table XXV (cont'd.)

Gross Weight 14,000 to 15,000 lb
Altitude 0-500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8					1					1
0.7										0
0.6										0
0.5					1	4	1			6
0.4				1	4	5	10	6		26
0.3			4	9	26	26	63	37		165
0.2		36	53	63	139	145	264	246		946
-0.2										0
-0.3		8	6	20	61	104	199	143		541
-0.4		4	3	2	16	14	20	21		80
-0.5		1			1		5	3		10
-0.6					1					1
-0.8										0
LESS										0
TOTAL	0	49	66	95	250	298	562	456	0	1776
MIN.	0.4	134.7	133.6	109.5	166.5	189.1	265.1	271.2	0.	1270.3

Gross Weight 15,000 to 16,000 lb
Altitude 0-500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4					4	2		3		9
0.3		1	1	7	13	24	20	45		111
0.2		28	35	53	112	188	233	282		931
-0.2										0
-0.3		10	13	7	32	67	157	176		462
-0.4		1	4	2	3	7	17	20		54
-0.5					1	2	4	5		12
-0.6										0
-0.8										0
LESS										0
TOTAL	0	40	53	69	165	290	431	531	0	1579
MIN.	0.5	126.6	120.5	117.5	166.7	215.0	267.5	273.1	0.9	1288.5

Gross Weight 16,000 to 17,000 lb
Altitude 0-500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5		1				1	1			3
0.4		2		2	1		2	2		9
0.3		3	1	6	20	18	20	19		87
0.2		34	25	62	124	169	136	142		692
-0.2										0
-0.3		22	14	19	31	48	72	88		294
-0.4		12	3	2	4	5	14	4		44
-0.5		1	1			1				3
-0.6										0
-0.8										0
LESS										0
TOTAL	0	75	44	91	180	242	245	255	0	1132
MIN.	1.1	169.2	130.5	119.2	195.0	211.2	210.4	180.1	0.2	1217.1

Table XXV (cont'd.)

Gross Weight 17,000 to 18,000 lb
Altitude 0-500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5			1							1
0.4		1				1	1			3
0.3			1	7	6	10	9	7		40
0.2		6	14	36	102	121	138	91		508
-0.2										0
-0.3		2	2	5	24	43	62	45		183
-0.4						4	11	2		17
-0.5						1	1			2
-0.6								1		1
-0.6										0
LESS										0
TOTAL	0	9	18	48	132	180	222	146	0	755
MIN.	1.0	99.4	102.7	105.3	191.5	190.3	203.6	142.1	0.3	1036.5

Gross Weight 18,000 to 19,000 lb
Altitude 0-500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4					1	2	2			5
0.3				3	7	7	7	3		27
0.2		4	1	14	37	59	45	33		193
-0.2										0
-0.3			1	4	6	22	20	16		69
-0.4					1	2	4	1		8
-0.5										0
-0.6										0
-0.8										0
LESS										0
TOTAL	0	4	2	21	52	92	78	53	0	302
MIN.	0.2	41.9	44.9	50.2	92.8	92.6	94.6	52.9	0.	470.2

Gross Weight 12,000 to 13,000 lb
Altitude 500-1000 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6							2	1		3
0.5						1	2	5		8
0.4						3	18	14		35
0.3				1	3	22	74	75		175
0.2		6	5	4	26	91	329	365		826
-0.2										0
-0.3		7		4	16	87	214	297		625
-0.4				1	3	12	58	60		134
-0.5		1					8	16		25
-0.6						1	3	1		5
-0.8										0
LESS										0
TOTAL	0	14	5	10	48	217	[illegible]	[illegible]	0	1836
MIN.	0.1	11.4	4.3	6.0	24.4	109.6	231.3	[illegible]	0.1	603.5

Table XXV (cont'd.)

Gross Weight 13,000 to 14,000 lb
Altitude 500-1000 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7					1					1
0.6						1	1	1		3
0.5						2	3			5
0.4					3	10	20	22		55
0.3				3	13	31	75	97		219
0.2		1		8	43	123	349	513		1037
-0.2										0
-0.3				2	34	70	305	404		815
-0.4					2	20	66	59		147
-0.5							15	13		28
-0.6								1		1
-0.8										0
LESS										0
TOTAL	0	1	0	13	96	257	834	1110	0	2311
MIN.	0.	0.2	2.6	6.6	25.2	91.1	302.8	451.2	0.	879.9

Gross Weight 14,000 to 15,000 lb
Altitude 500-1000 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6								1		1
0.5					1	1	6	2		10
0.4						7	18	29		54
0.3				3	8	16	96	162		285
0.2			2	4	33	114	505	960		1618
-0.2										0
-0.3				8	23	74	460	780		1345
-0.4					4	27	89	120		240
-0.5					1	3	18	16		38
-0.6							3	1		4
-0.8							1	2		3
LESS										0
TOTAL	0	0	2	15	70	242	1196	2073	0	3598
MIN.	0.	1.2	2.8	6.4	35.9	107.8	466.5	916.5	0.	1537.2

Gross Weight 15,000 to 16,000 lb
Altitude 500-1000 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6					1	2	1			4
0.5						2		1		3
0.4					2	3	6	22		33
0.3				4	9	16	61	163		253
0.2			1	8	20	87	507	1068		1691
-0.2										0
-0.3				6	8	39	471	735		1259
-0.4					3	8	101	133		245
-0.5					2	1	10	23		36
-0.6				1		1		1		3
-0.8								1		1
LESS										0
TOTAL	0	0	1	19	45	159	1157	2147	0	3528
MIN.	0.	7.6	4.5	9.9	23.7	93.7	472.7	911.0	1.3	1524.4

Table XXV (cont'd.)

Gross Weight 16,000 to 17,000 lb
Altitude 500-1000 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5						2				2
0.4					1		8	8		17
0.3				2	5	9	53	45	2	116
0.2				7	21	59	359	549	3	998
-0.2										0
-0.3		1			10	44	349	407	7	818
-0.4					2	5	43	48		98
-0.5				1		2	6	4		13
-0.6							1			1
-0.8										0
LESS										0
TOTAL	0	1	0	10	39	121	819	1061	12	2063
MIN.	0.	1.4	3.9	6.5	34.8	99.0	460.6	642.2	4.2	1252.7

Gross Weight 17,000 to 18,000 lb
Altitude 500-1000 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6							1			1
0.5						1				1
0.4						2	4	6		12
0.3					3	10	52	75		140
0.2				2	18	83	385	545		1033
-0.2										0
-0.3					5	39	325	409		778
-0.4					2	10	47	49		106
-0.5						2	7	4		13
-0.6							1	3		4
-0.8						1				1
LESS										0
TOTAL	0	0	0	2	28	148	822	1091	0	2091
MIN.	0.	0.2	0.6	3.8	30.7	129.8	513.2	605.4	1.2	1285.0

Gross Weight 18,000 to 19,000 lb
Altitude 500-1000 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5						3				3
0.4							2	1		3
0.3						7	33	27		67
0.2				1	6	34	203	144		388
-0.2										0
-0.3					4	28	204	106		342
-0.4						4	27	16		47
-0.5							3	3		6
-0.6						1	1	1		3
-0.8										0
LESS										0
TOTAL	0	0	0	1	10	77	473	298	0	859
MIN.	0.	0.1	1.4	3.3	17.3	70.6	306.3	219.7	0.	618.9

Table XXV (cont'd.)

Gross Weight 12,000 to 13,000 lb
Altitude 1000-1500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8							1			1
0.7										0
0.6						1	2	3		6
0.5						2	6	4		12
0.4						5	8	14		27
0.3				1	5	17	57	49		129
0.2			1	3	18	80	182	188	2	474
-0.2										0
-0.3				1	15	55	154	144		369
-0.4					3	13	47	51		114
-0.5							14	9		24
-0.6						1	3	5		9
-0.8										0
LESS										0
TOTAL	0	0	1	5	41	175	474	467	2	1165
MIN.	0.	0.4	0.8	1.0	22.3	56.4	116.5	99.5	1.3	298.3

Gross Weight 13,000 to 14,000 lb
Altitude 1000-1500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0								1		1
0.9										0
0.8										0
0.7										0
0.6								1		1
0.5							1	6		7
0.4					1	2	4	17		24
0.3				1	1	10	35	81		128
0.2					12	33	170	335		550
-0.2										0
-0.3				1	8	23	155	311		498
-0.4					1	8	60	63		132
-0.5						2	8	11		21
-0.6							3	2		5
-0.8								1		1
LESS										0
TOTAL	0	0	0	2	23	78	436	829	0	1368
MIN.	0.	0.5	1.6	2.1	9.6	29.7	119.2	249.3	0.1	412.2

Gross Weight 14,000 to 15,000 lb
Altitude 1000-1500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7							2			2
0.6							3	2		5
0.5							4	6		10
0.4				1	1	1	23	19		45
0.3					2	12	100	126		240
0.2		2	1	2	10	28	343	598		984
-0.2										0
-0.3			1	2	14	55	340	502		914
-0.4				1	2	10	89	116		218
-0.5					2	1	18	20		41
-0.6							3	2		5
-0.8								1		1
LESS										0
TOTAL	0	2	2	6	31	107	925	1392	0	2465
MIN.	0.	5.0	3.7	3.6	12.1	38.7	221.0	365.4	0.	649.5

Table XXV (cont'd.)

Gross Weight 15,000 to 16,000 lb
Altitude 1000-1500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6							1	1		2
0.5							1	3		4
0.4					1	1	8	16		26
0.3					1	8	40	72		121
0.2			1	3	10	37	227	387		665
-0.2										0
-0.3		1		5	8	27	247	354		642
-0.4						7	35	83		125
-0.5						1	10	8		19
-0.6							3	1		4
-0.8										0
LESS										0
TOTAL	0	1	1	8	20	81	572	925	0	1608
MIN.	0.	1.3	3.2	5.0	7.4	26.6	198.1	358.2	0.6	600.7

Gross Weight 16,000 to 17,000 lb
Altitude 1000-1500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5						1	1			2
0.4							5	5		10
0.3				1	3	6	21	45		76
0.2			1	4	21	23	130	277		456
-0.2										0
-0.3			2	6	6	24	155	232		425
-0.4				2		6	36	42		86
-0.5						1	7	6		14
-0.6							1			1
-0.8										0
LESS										0
TOTAL	0	0	3	13	30	61	356	607	0	1070
MIN.	0.	0.3	2.9	5.1	29.0	30.3	155.6	257.3	0.	480.6

Gross Weight 17,000 to 18,000 lb
Altitude 1000-1500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5							3			3
0.4						1	4	4		9
0.3						1	41	35		77
0.2					1	11	196	252		460
-0.2										0
-0.3					1	9	199	226		435
-0.4						1	30	25		56
-0.5								1		1
-0.6							3	1		4
-0.8										0
LESS										0
TOTAL	0	0	0	0	2	23	476	544	0	1045
MIN.	0.	0.	0.	0.3	2.3	30.9	262.7	284.3	0.	580.4

Table XXV (cont'd.)

Gross Weight 18,000 to 19,000 lb
Altitude 1000-1500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4							4	3		7
0.3						1	18	13		32
0.2				2	1	5	142	163		313
-0.2										0
-0.3						11	152	130		293
-0.4						1	24	18		43
-0.5						1	3	1		5
-0.6							2			2
-0.8										0
LESS										0
TOTAL	0	0	0	2	1	19	345	328	0	695
MIN.	0.	0.	0.	0.9	2.4	16.3	214.0	163.7	0.	397.4

Gross Weight 12,000 to 13,000 lb
Altitude 1500-2000 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6						1	2			3
0.5							2			2
0.4					1	2	7	6		16
0.3					2	3	26	20		51
0.2					7	24	77	86		194
-0.2										0
-0.3				1	5	19	81	83		189
-0.4						4	29	18		51
-0.5						2	8	4		14
-0.6							1	1		2
-0.8										0
LESS										0
TOTAL	0	0	0	1	15	55	233	218	0	522
MIN.	0.	0.2	0.3	1.2	9.0	19.6	47.9	49.5	0.	127.7

Gross Weight 13,000 to 14,000 lb
Altitude 1500-2000 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6								1		1
0.5							1			1
0.4							6	2		8
0.3						2	18	15		35
0.2					1	1	47	72		121
-0.2										0
-0.3						5	45	73		123
-0.4							15	17		32
-0.5							5	8		13
-0.6										0
-0.8							1			1
LESS										0
TOTAL	0	0	0	0	1	8	138	188	0	335
MIN.	0.	0.	0.2	0.5	3.0	3.9	22.7	32.9	0.	63.2

Table XXV (cont'd.)

Gross Weight 14,000 to 15,000 lb
Altitude 1500-2000 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.										0
1.0										0
0.9							1			1
0.8										0
0.7										0
0.6							2			2
0.5						1	3	1		5
0.4							16	9		25
0.3				1	2	5	65	43		116
0.2				1	7	14	210	171		403
-0.2										0
-0.3				2	6	19	245	155		427
-0.4						3	66	48		117
-0.5							10	11		21
-0.6							7	1		8
-0.8										0
LESS										0
TOTAL	0	0	0	4	15	42	625	439	0	1125
MIN.	0.	0.	0.	2.4	5.8	15.3	100.0	71.5	0.	195.0

Gross Weight 15,000 to 16,000 lb
Altitude 1500-2000 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6								1		1
0.5								3		3
0.4							7	4		11
0.3						6	29	24		59
0.2				2	6	10	98	67		183
-0.2										0
-0.3				1	3	13	108	74		199
-0.4					1	3	23	16		43
-0.5							4	2		6
-0.6										0
-0.8							2			2
LESS										0
TOTAL	0	0	0	3	10	32	271	191	0	507
MIN.	0.	0.	0.2	1.7	2.8	9.6	71.1	48.1	0.	133.5

Gross Weight 16,000 to 17,000 lb
Altitude 1500-2000 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5						1	1			2
0.4							2	3		5
0.3				1	1	1	9	5		17
0.2					3	4	54	44		105
-0.2										0
-0.3						8	57	36		101
-0.4					1		5	8		14
-0.5						1		1		2
-0.6							1			1
-0.8										0
LESS										0
TOTAL	0	0	0	1	5	15	129	97	0	247
MIN.	0.	0.	0.1	0.5	1.1	5.3	37.3	45.1	0.4	89.9

Table XXV (cont'd.)

Gross Weight 17,000 to 18,000 lb
Altitude 1500-2000 ft

Delta n_z	Tip Speed Ratio, μ: LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4										0
0.3							7	11		18
0.2						1	60	42		103
-0.2										0
-0.3						3	64	49		116
-0.4							13	5		18
-0.5							1	2		3
-0.6										0
-0.8										0
LESS										0
TOTAL	0	0	0	0	0	4	145	109	0	258
MIN.	0.	0.	0.	0.	0.	4.1	75.9	39.1	0.	119.1

Gross Weight 18,000 to 19,000 lb
Altitude 1500-2000 ft

Delta n_z	Tip Speed Ratio, μ: LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4							1			1
0.3							1	4		5
0.2							23	18		41
-0.2										0
-0.3							27	20		47
-0.4						1	2	3		6
-0.5							1			1
-0.6										0
-0.8										0
LESS										0
TOTAL	0	0	0	0	0	1	55	45	0	101
MIN.	0.	0.	0.	0.	0.4	3.0	35.4	15.7	0.	54.5

Gross Weight 12,000 to 13,000 lb
Altitude 2000-2500 ft

Delta n_z	Tip Speed Ratio, μ: LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5						1		1		2
0.4						1	4			5
0.3						6	15	2		23
0.2					3	7	54	26		90
-0.2										0
-0.3					1	13	51	27		92
-0.4					2	4	10	5		21
-0.5							9	1		10
-0.6								1		1
-0.8							1			1
LESS										0
TOTAL	0	0	0	0	6	32	144	63	0	245
MIN.	0.	0.3	0.1	0.1	3.2	17.9	44.0	24.0	0.	89.7

Table XXV (cont'd.)

Gross Weight 13,000 to 14,000 lb
Altitude 2000-2500 ft

Tip Speed Ratio, μ

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4							1	1		2
0.3							1	4		5
0.2						2	11	7		20
-0.2										0
-0.3							4	7		11
-0.4							2	2		4
-0.5							1	1		2
-0.6								1		1
-0.8										0
LESS										0
TOTAL	0	0	0	0	0	2	20	23	0	45
MIN.	0.	0.	0.4	0.	0.6	2.2	7.0	3.0	0.	13.2

Gross Weight 14,000 to 15,000 lb
Altitude 2000-2500 ft

Tip Speed Ratio, μ

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4										0
0.3						2	14	7		23
0.2							50	19		69
-0.2										0
-0.3						5	45	16		66
-0.4						1	12	6		19
-0.5							3			3
-0.6										0
-0.8										0
LESS										0
TOTAL	0	0	0	0	0	8	124	48	0	180
MIN.	0.	0.	0.	0.	0.2	1.1	20.3	9.0	0.	30.6

Gross Weight 15,000 to 16,000 lb
Altitude 2000-2500 ft

Tip Speed Ratio, μ

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6							1			1
0.5							1			1
0.4							2	1		3
0.3							11	4		15
0.2						1	22	2		25
-0.2										0
-0.3							23	8		31
-0.4							6	1		7
-0.5							2	1		3
-0.6										0
-0.8										0
LESS										0
TOTAL	0	0	0	0	0	1	68	17	0	86
MIN.	0.	0.	0.4	0.3	0.	0.2	16.8	4.9	0.	22.6

Table XXV (cont'd.)

Gross Weight 16,000 to 17,000 lb
Altitude 2000-2500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4										0
0.3							10			10
0.2							32	4		36
-0.2										0
-0.3						1	30	2		33
-0.4				1			4	2		7
-0.5										0
-0.6										0
-0.8										0
LESS										0
TOTAL	0	0	0	1	0	1	76	8	0	86
MIN.	0.	0.	0.	0.2	0.	0.6	17.8	1.8	0.	20.4

Gross Weight 17,000 to 18,000 lb
Altitude 2000-2500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4										0
0.3							1			1
0.2							6			6
-0.2										0
-0.3							7			7
-0.4										0
-0.5										0
-0.6										0
-0.8										0
LESS										0
TOTAL	0	0	0	0	0	0	14	0	0	14
MIN.	0.	0.	0.	0.	0.	0.6	8.8	0.8	0.	10.2

Gross Weight 18,000 to 19,000 lb
Altitude 2000-2500 ft

Delta n_z	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4										0
0.3										0
0.2							15	1		16
-0.2										0
-0.3							11	2		13
-0.4							2			2
-0.5										0
-0.6										0
-0.8										0
LESS										0
TOTAL	0	0	0	0	0	0	28	3	0	31
MIN.	0.	0.	0.	0.	0.	0.	17.5	1.3	0.	18.8

Table XXV (cont'd.)

Gross Weight 12,000 to 13,000 lb
Altitude 2500-3000 ft

Tip Speed Ratio, μ

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5							1	1		2
0.4								1		1
0.3					1		2			3
0.2						6	23	18		47
-0.2										0
-0.3					2	11	34	23		70
-0.4						1	8	7		16
-0.5					1		3			4
-0.6										0
-0.8										0
LESS										0
TOTAL	0	0	0	0	4	18	71	50	0	143
MIN.	0.	0.	0.	0.6	5.5	21.5	27.8	11.9	0.	67.4

Gross Weight 13,000 to 14,000 lb
Altitude 2500-3000 ft

Tip Speed Ratio, μ

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4										0
0.3										0
0.2						3	2			5
-0.2										0
-0.3						1				1
-0.4										0
-0.5										0
-0.6										0
-0.8										0
LESS										0
TOTAL	0	0	0	0	0	4	2	0	0	6
MIN.	0.	0.	0.4	0.4	0.9	14.7	10.7	0.1	0.	27.2

Gross Weight 16,000 to 17,000 lb
Altitude 2500-3000 ft

Tip Speed Ratio, μ

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5										0
0.4										0
0.3										0
0.2						1	2			3
-0.2										0
-0.3						1				1
-0.4						1				1
-0.5										0
-0.6						1				1
-0.8										0
LESS										0
TOTAL	0	0	0	0	0	4	2	0	0	6
MIN.	0.	0.	0.	0.	0.4	2.6	2.9	0.	0.	5.9

Table XXVI

Peak Delta n_z versus Tip Speed Ratio, μ, by Altitude Ranges

Tip Speed Ratio, μ — Altitude 0-500 ft

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8					1					1
0.7										0
0.6					1	1	1			3
0.5		1	1	1	5	8	3	3		22
0.4		5	1	5	19	30	27	25		112
0.3		10	15	49	112	140	176	171	1	674
0.2		182	[illegible]06	317	690	934	1107	1122		4558
-0.2										0
-0.3		60	56	80	257	391	691	681		2216
-0.4		21	13	11	44	54	97	80		320
-0.5		3	1		4	6	14	22		50
-0.6					1		1	3		5
-0.8					1		2			3
LESS										0
TOTAL	0	292	293	463	1135	1564	2119	2107	1	7964
MIN.	7.3	853.0	714.1	618.6	992.1	1110.6	1288.0	1143.0	2.1	6729.0

Tip Speed Ratio, μ — Altitude 500-1000 ft

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7					1					1
0.6					1	3	5	3		12
0.5					1	12	11	8		32
0.4					6	25	76	102		209
0.3				13	41	111	444	644	2	1255
0.2		7	8	34	167	591	2637	4144	3	7591
-0.2										0
-0.3		8		20	100	381	2328	3138	7	5982
-0.4				1	16	86	431	485		1019
-0.5		1		1	3	8	67	79		159
-0.6				1		3	9	8		21
-0.8						1	1	3		5
LESS										0
TOTAL	0	16	8	70	336	1221	6009	8614	12	16286
MIN.	0.1	22.2	20.2	42.6	192.1	701.8	2753.5	3962.3	6.8	7701.7

Tip Speed Ratio, μ — Altitude 1000-1500 ft

Delta n_z	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
1.4										0
1.2										0
1.0								1		1
0.9										0
0.8							1			1
0.7							2			2
0.6						1	6	7		14
0.5						3	16	19		38
0.4				1	3	10	56	78		148
0.3				3	12	55	312	421		803
0.2		2	4	14	73	217	1390	2200	2	3902
-0.2										0
-0.3		1	3	15	52	204	1402	1899		3576
-0.4				3	6	46	321	398		774
-0.5					2	7	60	56		125
-0.6						1	18	11		30
-0.8								2		2
LESS										0
TOTAL	0	3	7	36	148	544	3584	5092	2	9416
MIN.	0.	7.5	12.2	18.0	85.2	229.0	1287.2	1777.8	2.2	3419.3

Table XXVI (cont'd.)

Delta n_z	LESS	0.00	0.05	0.10	0.15 (Tip Speed Ratio, μ)	0.20	0.25	0.30	0.35	TOTAL (Altitude 1500-2000 ft)
1.4										0
1.2										0
1.0										0
0.9							1			1
0.8										0
0.7										0
0.6						1	4	2		7
0.5						2	7	4		13
0.4					1	2	39	24		66
0.3				2	5	17	155	122		301
0.2				3	24	54	569	500		1150
-0.2										0
-0.3				4	14	67	627	490		1202
-0.4					2	11	153	115		281
-0.5						3	29	28		60
-0.6							9	2		11
-0.8							3			3
LESS										0
TOTAL	0	0	0	9	46	157	1596	1287	0	3095
MIN.	0.	0.2	0.8	6.3	22.1	60.8	390.4	302.0	0.4	783.0

Delta n_z	LESS	0.00	0.05	0.10	0.15 (Tip Speed Ratio, μ)	0.20	0.25	0.30	0.35	TOTAL (Altitude 2000-2500 ft)
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6							1			1
0.5						1	1	1		3
0.4						1	7	2		10
0.3						8	52	17		77
0.2					3	10	190	59		262
-0.2										0
-0.3					1	19	171	62		253
-0.4				1	2	5	36	16		60
-0.5							15	3		18
-0.6								2		2
-0.8							1			1
LESS										0
TOTAL	0	0	0	1	6	44	474	162	0	687
MIN.	0.	0.3	0.9	0.6	4.0	22.6	132.3	44.8	0.	205.6

Delta n_z	LESS	0.00	0.05	0.10	0.15 (Tip Speed Ratio, μ)	0.20	0.25	0.30	0.35	TOTAL (Altitude 2500-3000 ft)
1.4										0
1.2										0
1.0										0
0.9										0
0.8										0
0.7										0
0.6										0
0.5							1	1		2
0.4								1		1
0.3					1		2			3
0.2						10	27	18		55
-0.2										0
-0.3					2	13	34	23		72
-0.4						2	8	7		17
-0.5					1		3			4
-0.6						1				1
-0.8										0
LESS										0
TOTAL	0	0	0	0	4	26	75	50	0	155
MIN.	0.	0.	0.4	1.0	6.8	39.4	43.3	12.0	0.	102.9

Table XXVII

Peak Pitch Rates versus Tip Speed Ratio, μ, by Mission Segment

Mission Segment Takeoff and Ascent

Pitch Rate - °/sec	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS										0
-12										0
-10		2	1							3
-8		139	102	10	7	7	3			268
-6	9	730	378	50	65	68	68	6		1374
-4	12	1259	908	556	916	1737	1761	244		7393
-2										0
0										0
2	6	883	681	1180	2390	2876	1889	286		10191
4	1	120	53	109	206	226	100	15		830
6	1	9	9	12	21	18	4	4		78
8			1	1	2		1			5
10			1							1
12				1	1					2
TOTAL	29	3142	2134	1919	3608	4932	3826	555	0	20145
MIN.	2.1	250.9	223.2	242.0	532.1	942.0	798.5	123.0	0.	3114.0

Mission Segment Descent

Pitch Rate - °/sec	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS										0
-12										0
-10										0
-8		13	13	26	17	6	5	1		81
-6		38	60	94	87	53	112	35		479
-4		82	346	1050	1387	1421	2548	1540		8374
-2										0
0										0
2		74	386	2023	3281	3070	4897	2624	3	16358
4		20	56	304	495	256	203	61		1395
6		13	5	57	82	23	9	4		193
8		2	1	6	4	5				16
10		4	1	7	1	1	1			15
12			1	2						3
TOTAL	0	246	869	3569	5354	4835	7775	4265	3	26916
MIN.	0.	12.2	62.5	319.4	560.6	603.2	1193.0	931.4	1.3	3684.1

Mission Segment Flare and Landing

Pitch Rate - °/sec	Tip Speed Ratio, μ LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS										0
-12										0
-10										0
-8		46	119	6						173
-6	1	351	511	53	1					917
-4	9	2252	2659	412	31	1				5364
-2										0
0										0
2	2	899	1635	672	77	1				3286
4		54	143	74	3					274
6		5	11	5						21
8		1		1						2
10			2							2
12				1						1
TOTAL	12	3610	5080	1224	112	2	0	0	0	10040
MIN.	1.9	328.6	365.2	97.4	10.3	0.1	0.	0.	0.	803.8

Table XXVII (cont'd.)

Pitch Rate				Tip Speed Ratio, μ				Mission Segment Hover		
- °/sec	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS										0
-12										0
-10										0
-8		33	14							47
-6		157	46							203
-4	15	1474	341	1						1831
-2										0
0										0
2	13	1278	324							1615
4	2	142	46							190
6		31	14							45
8		3	4							7
10		2								2
12			1							1
TOTAL	30	3120	790	1	0	0	0	0	0	3941
MIN.	3.4	288.4	89.4	0.0	0.	0.	0.	0.	0.	381.3

Table XXVIII

Peak Pitch Rates versus Tip Speed Ratio, μ

Pitch Rate				Tip Speed Ratio, μ						
- °/sec	LESS	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	TOTAL
LESS										0
-12										0
-10		2	1							3
-8		233	246	42	24	13	8	1		569
-6	10	1276	995	197	153	121	180	41		2973
-4	36	5067	4254	2019	2334	3159	4309	1784		22962
-2										0
0										0
2	21	3134	3026	3875	5748	5947	6786	2910	3	31450
4	3	336	298	487	704	482	303	76		2689
6	1	58	39	74	103	41	13	8		337
8		6	6	8	6	5	1			32
10		6	4	7	1	1	1			20
12			2	4	1					7
TOTAL	71	10118	8873	6713	9074	9769	11601	4820	3	61042
MIN.	7.4	883.2	748.6	687.1	1302.3	2164.3	5894.7	7241.9	11.5	18941.2

APPENDIX

Data Recording System

The following treats of the description and operations of the data recording system.

Recorder - The recorder was the Model 414 Century oscillograph which was designed primarily for vehicles, such as aircraft and guided missiles, used in severe environments and with rigid space limitations. This instrument has the capability of recording simultaneously the data from 14 channels on a 3-5/8-inch-wide oscillogram, a photosensitive paper. The recorder measures 7 x 5-1/2 x 6-3/4 inches in height, width, and depth, respectively, and weighs 8 pounds; its power requirement is 28 volts D.C. at 2.5 amperes. The recorder magazine can contain 70 feet of oscillogram. When the 70-foot oscillogram is run at a 3-inch-per-minute paper speed, data can be recorded for 4 hours and 40 minutes.

Ten of the 14 channels were utilized: seven to record the respective seven parameters, an eighth to produce a static reference line superimposed on the pitch rate trace, a ninth to monitor the voltage supply, and a tenth to mark the cycling of a uniform period for time reference. Parameter trace variations from the static reference line were measured with the assumption of a constant transducer voltage supply. The trace monitoring this supply provided the means of detecting any voltage fluctuation and of adjusting for it during the computational phase of the data processing. The time signal emanating at one cycle per minute from an internal timing circuit excited the timing galvanometer to cause the delineation of a square-wave time pattern on the oscillogram. The timing circuit was a unijunction transistor trigger circuit operating in conjunction with a conventional multivibrator. Type 210C56-2 and 210C58-2 Century galvanometers were employed. Each has a D.C. sensitivity of 22 microamperes. The natural frequency of the former is 100 cps, and that of the latter is 30 cps. These galvanometers are of the magnetic damping type and require an external damping resistance of 350 ohms for a damping factor of 65 percent of critical. The magnetic block of the oscillograph was heated to a constant temperature to minimize galvanometer drift. Table A-1 lists the function and channel number assignments of the galvanometer types.

Bridge Balance and Signal Conditioning Unit - Attached to the oscillograph, the bridge balance and signal-conditioning unit included switches to control the data acquisition system and fuses for all power used by the system. In addition, this unit contains bridge balance, calibration, filtering and signal-conditioning

circuitry for all channels as well as the excitation voltage supply for all bridge-type sensors. Moreover, the unit served as a termination point for all signals to be recorded. The following paragraphs discuss the basic functions which this unit performed for each of the data channels.

TABLE A-1

Oscillograph Galvanometers Listed by Type, Function and Channel Assignment

Function	Channel Number	Century Galvanometer Type
Timing	T	210C56-2
Altitude	1	210C58-2
Dummy	2	200A12
Acceleration (n_z)	3	210C56-2
Dummy	4	200A12
Pitch Rate	5	210C56-2
Dummy	6	200A12
Airspeed	7	210C56-2
Static Reference	8	210C60-2
Rotor RPM (n_r)	9	210C56-2
Engine Torque I	10	210C56-2
Engir.e Torque II	11	210C56-2
Voltage Monitor	12	210C56-2
Dummy	13	200A12

Airspeed Transducer - The airspeed transducer was a 0- to 1- psid Statham unbonded strain gage pressure transducer, Model PL283TC-1-350. So that connections would not interfere with the SAS, the transducer was coupled to the pilot's pitot-static system, the static line connecting to the low side of the transducer and the pitot line to the high side. The resistance wire elements of the transducer were arranged in the form of a Wheatstone bridge. A series potentiometer at the bridge input permitted adjustment of the excitation voltage to the bridge. This voltage was supplied by the aircraft's 28-volt D. C. source and was regulated to 12 volts by a Zener diode regulator. A potentiometer connected across the input with the wiper to the low side of the bridge output adjusted the bridge output to zero voltage. The output voltage of the bridge was fed directly to a 100-cycle-per-second galvanometer in the recorder.

Altitude Transducer - The altitude transducer was a 0- to 15 - psia Statham unbonded strain gage pressure transducer, Model PA911TC-15-350. This transducer was connected to the pilot's static system. Except for the use of a 30-cycle-per-second galvanometer in the recorder, the electrical configuration and operation of this system was identical to that of the airspeed system.

Accelerometer - The acceleration at the helicopter's center of gravity was sensed by a $\pm$ 2.5-g Model 4-205 CEC accelerometer. This accelerometer is an unbonded strain gage transducer in a Wheatstone bridge configuration. Potentiometers in the bridge balance unit permitted adjustment of the bridge excitation voltage and bridge balancing. The bridge output voltage was fed to a 100-cycle-per-second galvanometer in the recorder.

Pitch Rate Gyro - The pitch rate of the craft was sensed by a $\pm$ 30-degree-per-second rate gyro, manufactured by Humphrey, Incorporated. Having a potentiometer output, this rate gyro was so connected in a Wheatstone bridge circuit that two of the arms were active while the other two each served as a dummy resistor, their resistance is one half of the total resistance of the potentiometer. A series potentiometer permitted adjustment of the bridge excitation voltage when a balance potentiometer was connected across the bridge excitation. Through an R-C filter with a cutoff frequency of 14 cycles per second, the output of the bridge was fed to a 100-cycle-per-second galvanometer in the recorder.

Rotor RPM Measurement - The rotor rpm was recorded by sampling one phase of the output of a three-phase rotor tachometer generator and feeding the signal to a frequency-to-D. C. converter. This converter reduced the variable-frequency signal from its original 13 to 20 volts to 5 volts and converted it to an equivalent D. C. voltage which deflected the 100-cycle-per-second galvanometer in the recorder in proportion to the rotor tachometer generator speed.

The signal was clipped to a low voltage to prevent the change in voltage from affecting the frequency-to-D. C. converter output, since the converter was sensitive to both frequency and voltage. Clipping the signal, therefore, made the circuit sensitive only to frequency.

Engine Torque Measurement - Torque measurements were taken of each of the two engines whose operations were identical. The A. C. amplitude-modulated signal outputs of the torque sensing units on each engine were fed to individual amplifier-demodulator units in the bridge balance and signal-conditioning unit where the millivolt outputs were amplified and demodulated and then fed to a 100-cycle-per-second galvanometer in the recorder. A

reference signal, required for the demodulation operation, was derived from phase B of the aircraft's A. C. power system and fed to the amplifier-demodulator units.

CALIBRATIONS

Transducers and other measuring systems were calibrated by applying known values of various stimuli and correlating them with the corresponding oscillogram trace deflections.

In this program, calibrations were of two types—laboratory and preflight. The former is an actual calibration of an instrument against controlled laboratory standards to yield oscillogram trace deflections corresponding to discrete input levels, and the latter is a synthetic calibration of an installed instrument before each flight to produce calibration pulses which correspond to known inputs and which are later compared with laboratory calibrations in the data processing.

Laboratory Calibrations

Laboratory calibrations using the oscillograph were performed in the manner discussed below.

Airspeed and Altitude Transducers - Mercury and water manometers served as pressure standards in performing laboratory calibrations of the airspeed and altitude transducers. With the manometers connected to the airspeed and altitude transducers, discrete pressure and vacuum values were applied. The bridge output voltages of the airspeed and altitude channels deflected the respective oscillogram traces distances which were analogous to the applied pressure. From the deflections for each transducer, a calibration slope in applied pressure per unit deflection was derived and subsequently used in the data processing computations.

Accelerometer - The accelerometer was calibrated in the laboratory by using a $\pm$ 1-g static calibration method. A zero-g line was established by placing the sensitive axis of the accelerometer parallel to the earth's surface. Then $\pm$ 1-g lines were determined by rotating the sensitive axis $\pm 90^{\circ}$ from its position parallel to the earth's surface. The distance between the zero and $\pm$ 1-g lines on the oscillogram represented a bridge output voltage corresponding to $\pm$ 1-g acceleration input. From this data, a calibration slope of g's per unit deflection was derived for subsequent data processing computations.

Rate Gyro - The rate gyro was calibrated in the laboratory by attaching it to a rate table which spun at controllable rates. As the rate table turned

at discrete angular rates, the gyro output was recorded on the oscillogram. From this data, a calibration slope of degrees per second per unit deflection was derived for subsequent data processing computations.

Engine Torque Measurement System - With the torque meter static calibration serving as an initial reference, the engine torque indication system was calibrated in the field by running the engine at various torque levels.

Rotor RPM Measurement System - The rotor rpm indication system was calibrated in the laboratory by using a variable-frequency signal generator to simulate the output of the rotor tachometer generator and in the field by noting the data displayed by the aircraft instruments.

Preflight Calibrations

To reflect environmental effects and instrumentation changes, the technician performed a preflight synthetic calibration on each oscillogram roll. When compared with the laboratory calibrations, these preflight calibrations permitted determining a calibration correction factor. A calibration resistor in the bridge circuit of each channel within the bridge balance unit provided the means of performing the synthetic calibration. When the manual calibration switch was thrown and the calibration resistor was consequently placed across one leg of the bridge, the bridge became unbalanced and thereby generated an output voltage analogous to a specific input of one of the measured parameters. The value of the calibration resistor Rcal was calculated by substituting the values on the transducer data sheet in the following equation:

$$Rcal = \frac{10^6 R}{4N\ F} - \frac{Rin + R}{4}$$

where

R = resistance between the output terminals of the transducer
Rin = input resistance
F = calibration factor
N = number of units of the variable for which the output is computed.

INSTALLATION

Installation of the data involved three major components: (1) recorder and bridge balance-signal conditioning unit, (2) air data system package, and (3) center of gravity package. Figures A-1 through A-11 show the installation and wiring details.

Recorder and Bridge Balance-Signal Conditioning Units

The recorder and bridge balance-signal conditioning units were installed together on a single bracket which was shock mounted to another bracket. The latter bracket was bolted to the aircraft structure on the right-hand side of the baggage pad area between FS 410 and FS 434. Figures A-2, A-4, A-5, and A-6 illustrate the installation.

Air Data System Package

The air data system package containing the altitude and airspeed transducers was mounted on a single bracket attached to a vertical panel forward of the co-pilot's instrument panel and adjacent to the Bendix VAF transceiver. Located approximately at FS 42, the package was located within 12 to 18 inches of the pitot-static tap-in points. The installation of this package is illustrated in Figures A-1, A-4, and A-7.

Center of Gravity Package

The center of gravity package containing the accelerometer and rate gyro was mounted to the airframe beneath the passenger floor near FS 286 and battlock line 0.0. In this positioning, the sensitive axis of the accelerometer was perpendicular to the craft's floor and the sensitive axis of the rate gyro was in the reference plane of the pitch angle. A protective covering was placed over the package to prevent accidental damage. Figures A-3, A-4, and A-8 show installation details.

Wiring

With the exception of the rotor tachometer generator input leads, all wiring from the recorder system was routed from the cargo area to the passenger area through the bulkhead at FS 410. The rotor tachometer generator wiring was routed along the tie-in points in the transmission area above the baggage pod. After passing through the bulkhead, the main cable bundle was routed under the passenger area floor between FS 382 and FS 410 to the left-hand side of the passenger compartment and then behind the side paneling to the cockpit. The main bundle followed existing cabling along this route and was laced to it, rather than held down by cable clamps. The center of gravity cable was routed from the main bundle at FS 320 and passed under the passenger floor to the center of gravity package. Wiring for the torque measurement system was tied into the helicopter system at TB 56 located behind the co-pilot's area. Figure A-4 indicates where the wiring is located. Figures A-8 through A-11 show additional wiring details.

Power

AC and DC power for the system was fed from existing circuit breakers on the pilot's overhead circuit-breaker console. The power leads were connected to the main bundle under the lower pedestal and routed directly to the recording system. Batteries to supply power for the rpm frequency-to-voltage converter and torque amplifiers were, respectively, a Gulton nickel cadmium 9-volt, 180-ma battery; and two Gulton nickel cadmium 14.4-volt, 500-ma batteries.

Helicopter, General Arrangement

Table A-2 and Figures A-12 and A-13 present the principal dimensions and general arrangement of the Boeing-Vertol 107-II helicopter. The general arrangement of the major components, shown in Figure A-2, shows a standard seating arrangement used for commercial passenger operation.

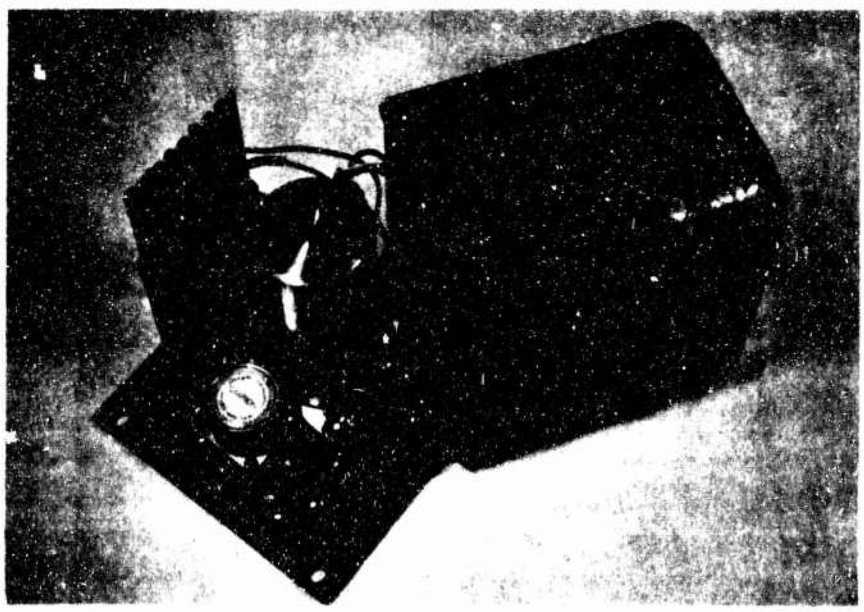
Table A-2

DIMENSIONS AND AREAS—GENERAL

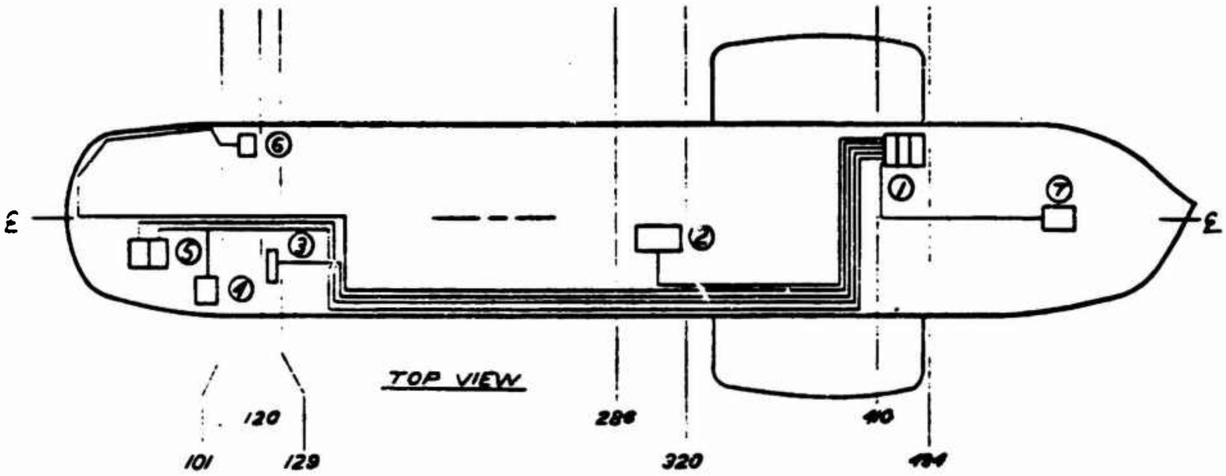
	Airliner and Utility Helicopters
1. Principal Dimensions (see Figure A-13)	
A. General	
Height (at aft rotor)	202.0 in.
Width (rotors turning)	600.0 in.
Width (rotors positioned)	526.0 in.
Length (rotors turning)	1000.0 in.
Length (rotors positioned)	861.0 in.
Length (rotors positioned and dephased)	722.0 in.
B. Fuselage	
Cabin height	86.0 in.
Cabin width	87.0 in.
Length	534.8 in.
Ground clearance	18.0 in.
Ramp entrance width	--
Ramp entrance height	--
C. Rotors	
Blade length	300.0 in.
Blade chord	18.0 in.
Rotor diameter	600.0 in.
Rotor overlap	200.0 in.
Ground clearance (minimum) on forward rotor with blades at rest	106.7 in.
D. Landing Gear	
Wheel base (static)	297.8 in.
Wheel tread	154.5 in.
Overall width at stub wing	174.2 in.
2. Principal Areas (see Figure A-13)	
A. General	
Rotor disk, each	1963.5 sq ft
Total rotor disk (less overlap)	3497.09 sq ft

A-1 Air Data System Transducers

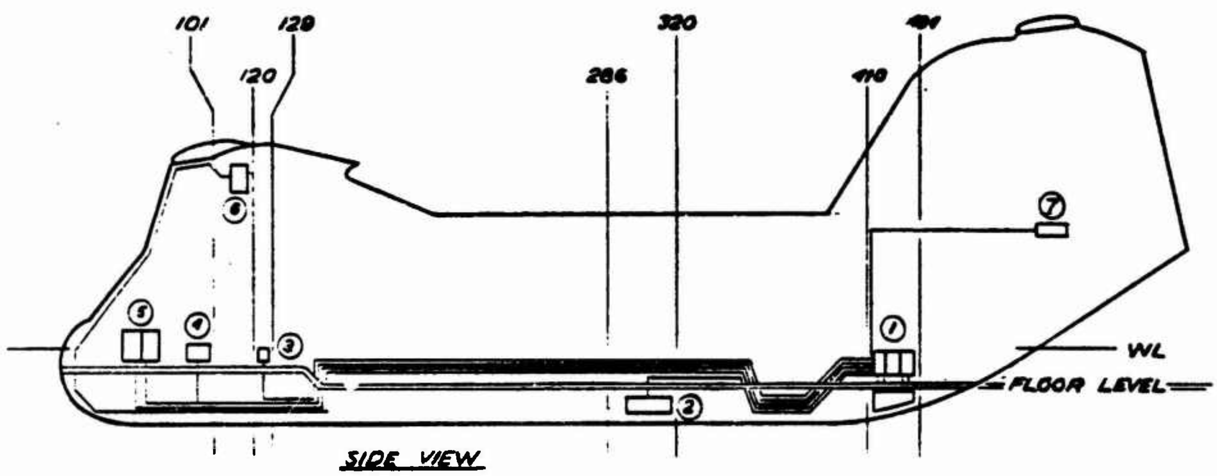
A-2 Oscillograph and Bridge Balance Box



A-3 Center of Gravity Data System Transducers



1 RECORDER, SIGNAL CONDITIONING UNIT, AND ISOLATION UNIT
2 C G PACKAGE
3 TB 5G
4 COLLECTIVE STICK MICRO SWITCH
5 ALTITUDE AND AIRSPEED PKG.
6 AC AND DC CKT BKS
7 AFT ROTOR TACH GEN.



1 RECORDER, SIGNAL CONDITIONING UNIT, AND ISOLATION UNIT
2 C G PACKAGE
3 TB 5G
4 COLLECTIVE STICK MICRO SWITCH
5 ALTITUDE AND AIRSPEED PKG
6 AC AND DC CKT BKS
7 AFT ROTOR TACH GEN.

Figure A-4. Instrumentation Installation Vertol 107-II Helicopter

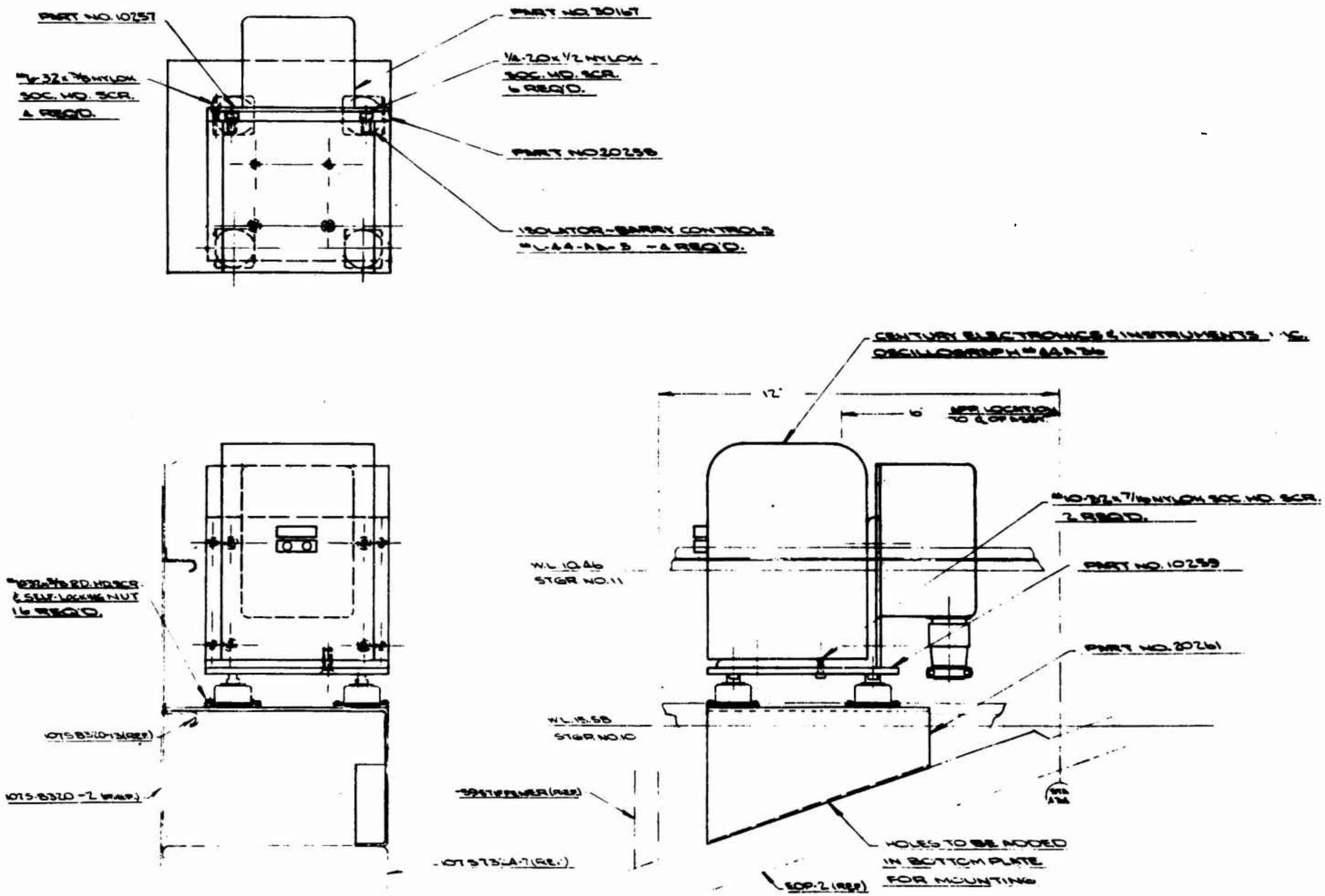


Figure A-5. Shock Mount - Oscillograph and Bridge Balance Box

Figure A-5. Shock Mount - Oscillograph and Bridge Balance Box

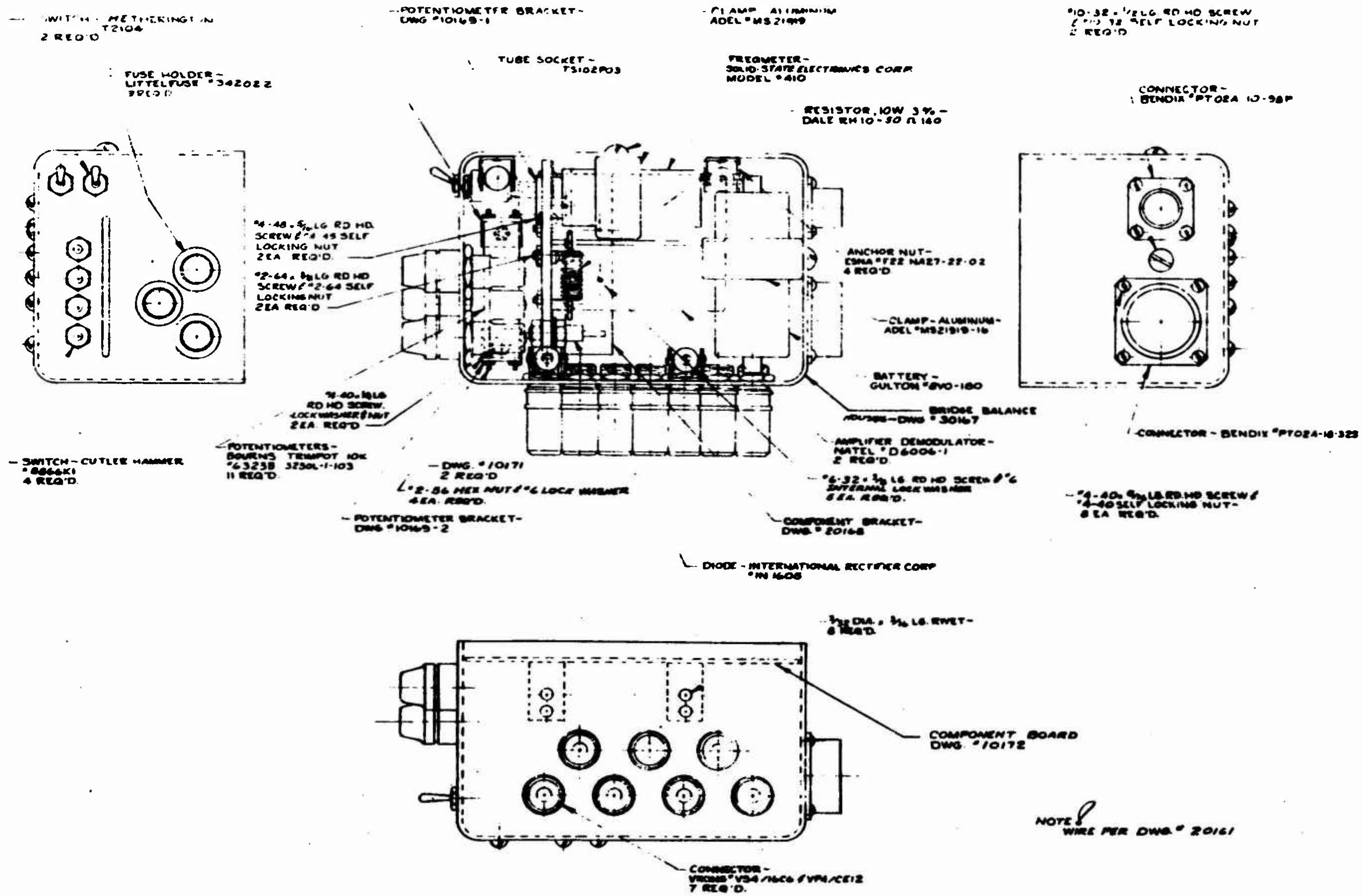
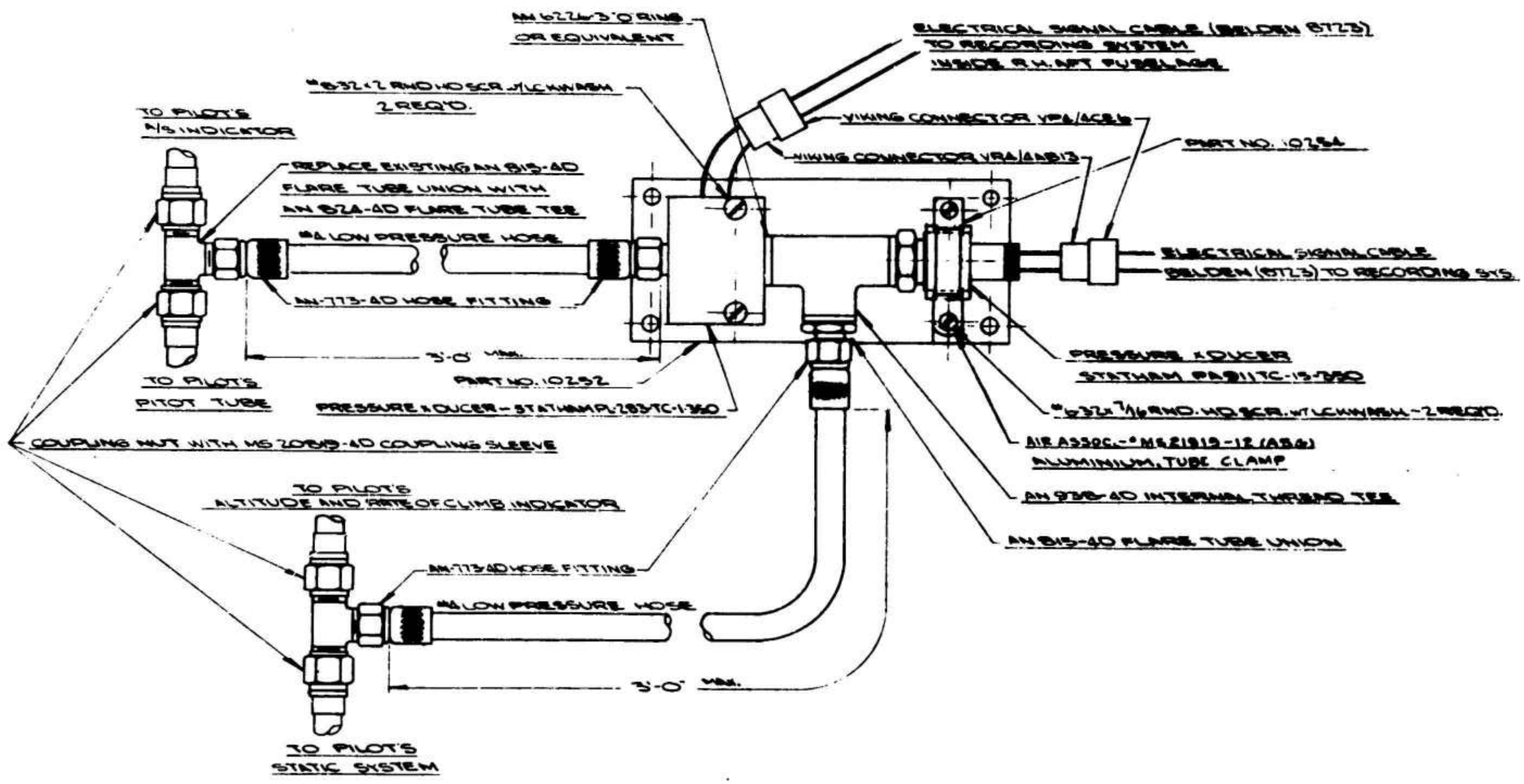


Figure A-6. Bridge Balance and Control Box Assembly



NOTES:

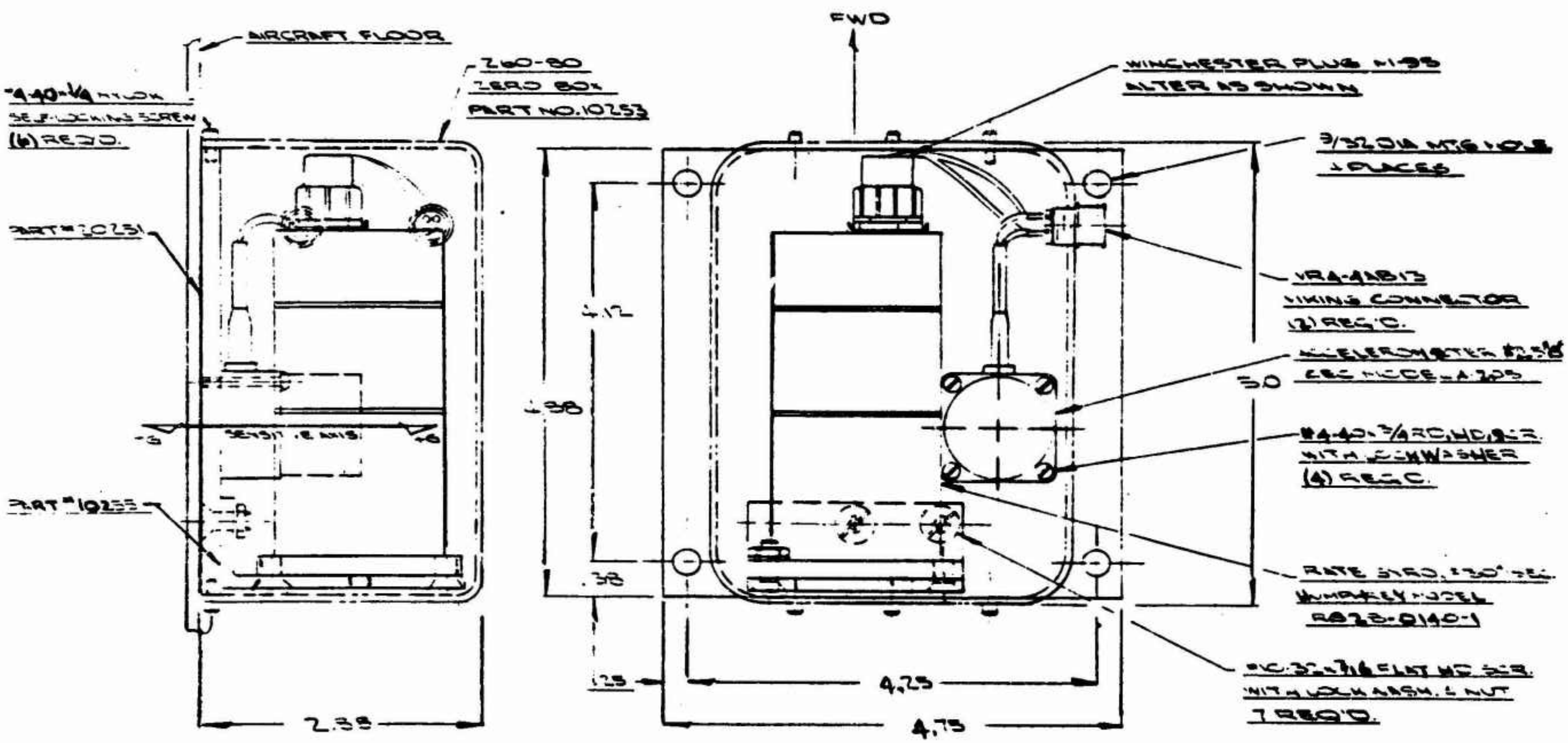
1) TAPING WILL BE MADE AT THE REAR OF THE COPILOT'S INSTRUMENT PANEL.

2) ELECTRICAL CABLE'S WILL BE ROUTED TO THE RECORDING SYSTEM VIA BEST ROUTE (TO BE DETERMINED BY NYA)

3) THIS ASSEMBLY TO BE MOUNTED TO FLOOR OR AVAILABLE BULKHEAD FORWARD OF COPILOT'S INSTRUMENT PANEL

4) EXACT MOUNTING TO BE DETERMINED AT INSTALLATION

Figure A-7. Air Data System



NOTES:

1. PACKAGE TO BE MOUNTED WITH ACCELEROMETER SENSITIVE AXIS PERPENDICULAR TO A/C FLOOR AND AS NEARLY AS POSSIBLE TO F.S. 280 AND BUTTOCK LINE 0.0 (UNDER OUTSIDE DUAL SEAT)
2. WIRING TO BE ROUTED BY BEST MEANS TO RECORDER LOCATED INSIDE R.H. AFT FUSELAGE
3. PRECISE CABLE ROUTING AND MOUNTING LOCATION TO BE DETERMINED AT INSTALLATION TIME

Figure A-8. Center of Gravity Instrumentation Package

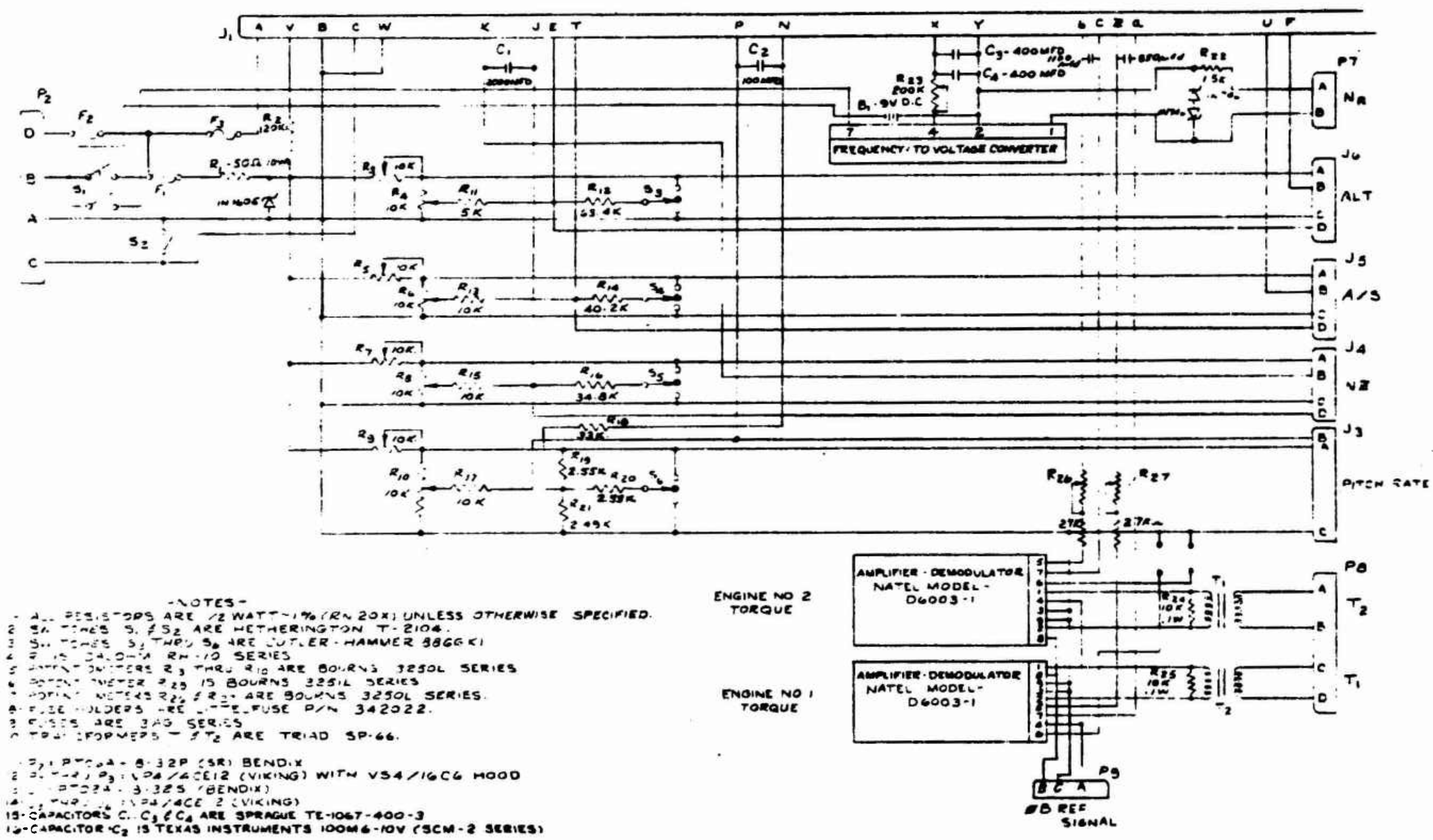


Figure A-9. Schematic - Bridge Balance and Signal Conditioning Unit

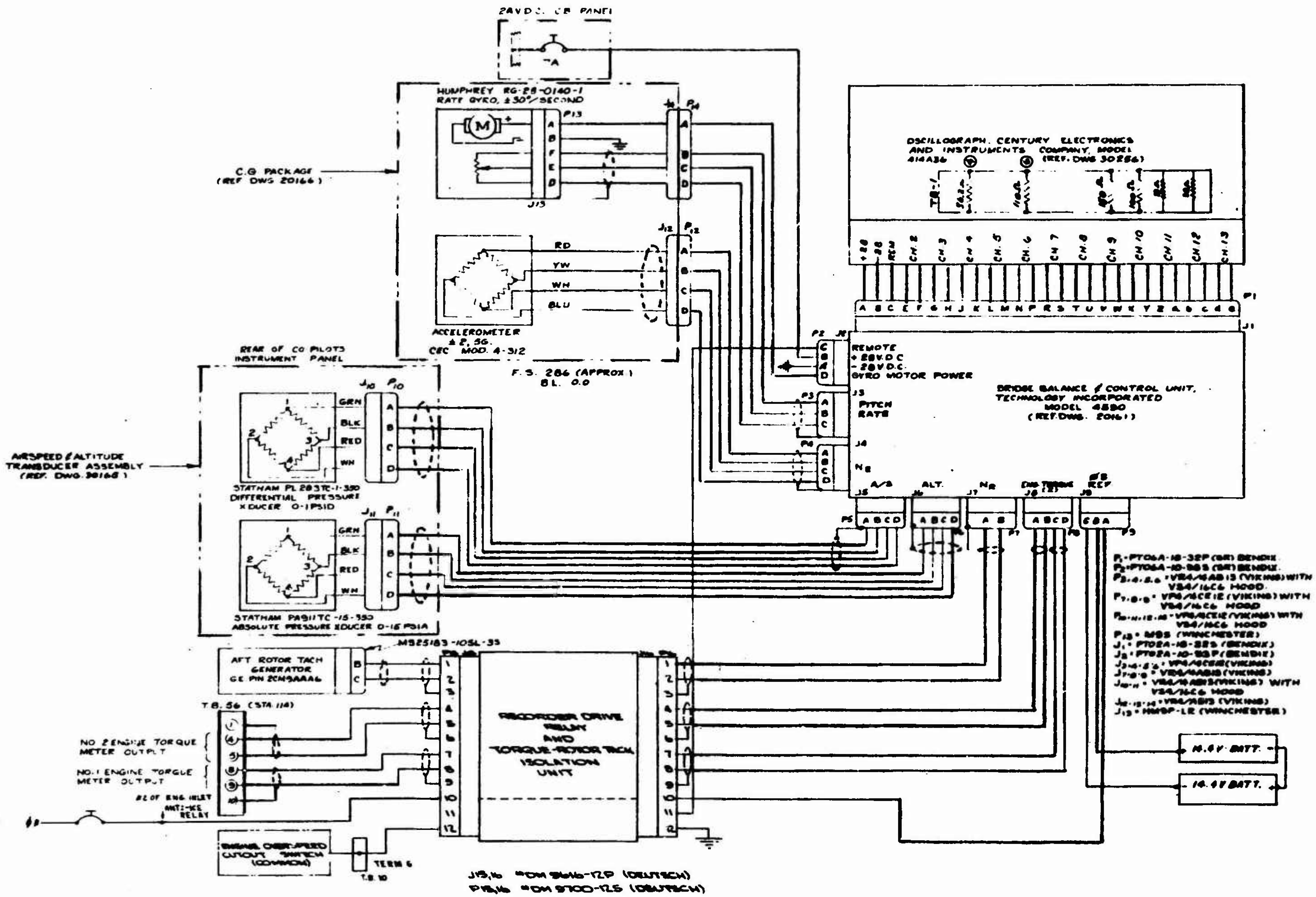


Figure A-10. Wiring Diagram - Recording System

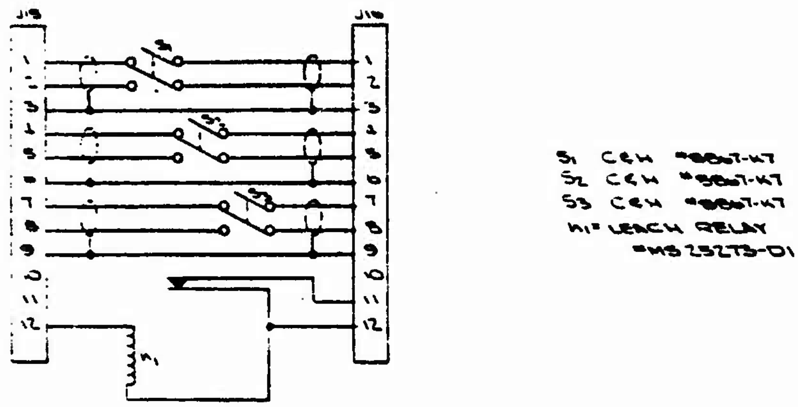


Figure A-11. Recorder Drive Relay and Torque-Rotor Tack Isolation Unit

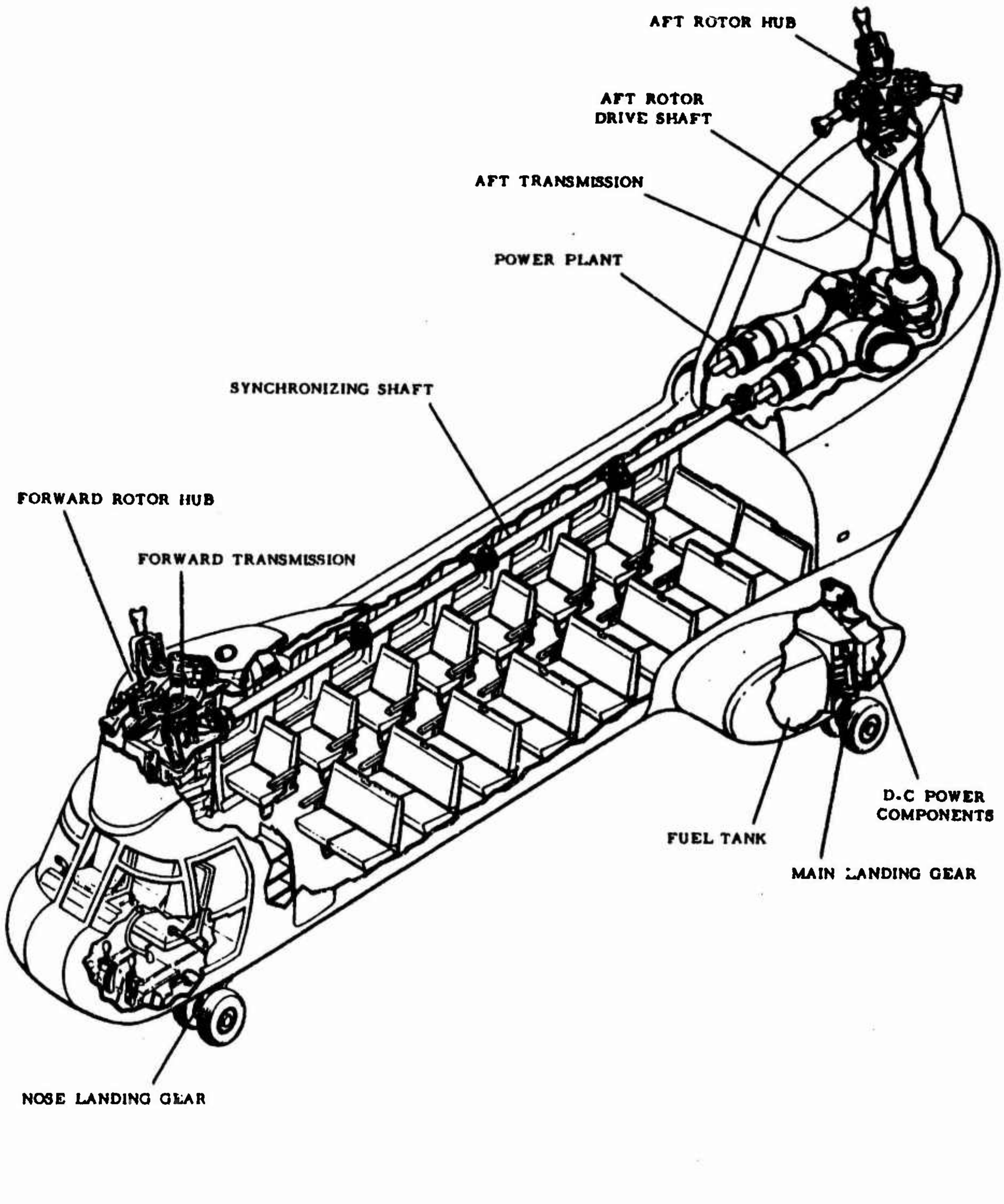


Figure A-12. General Arrangement and Major Components - Vertol 107-II Helicopter

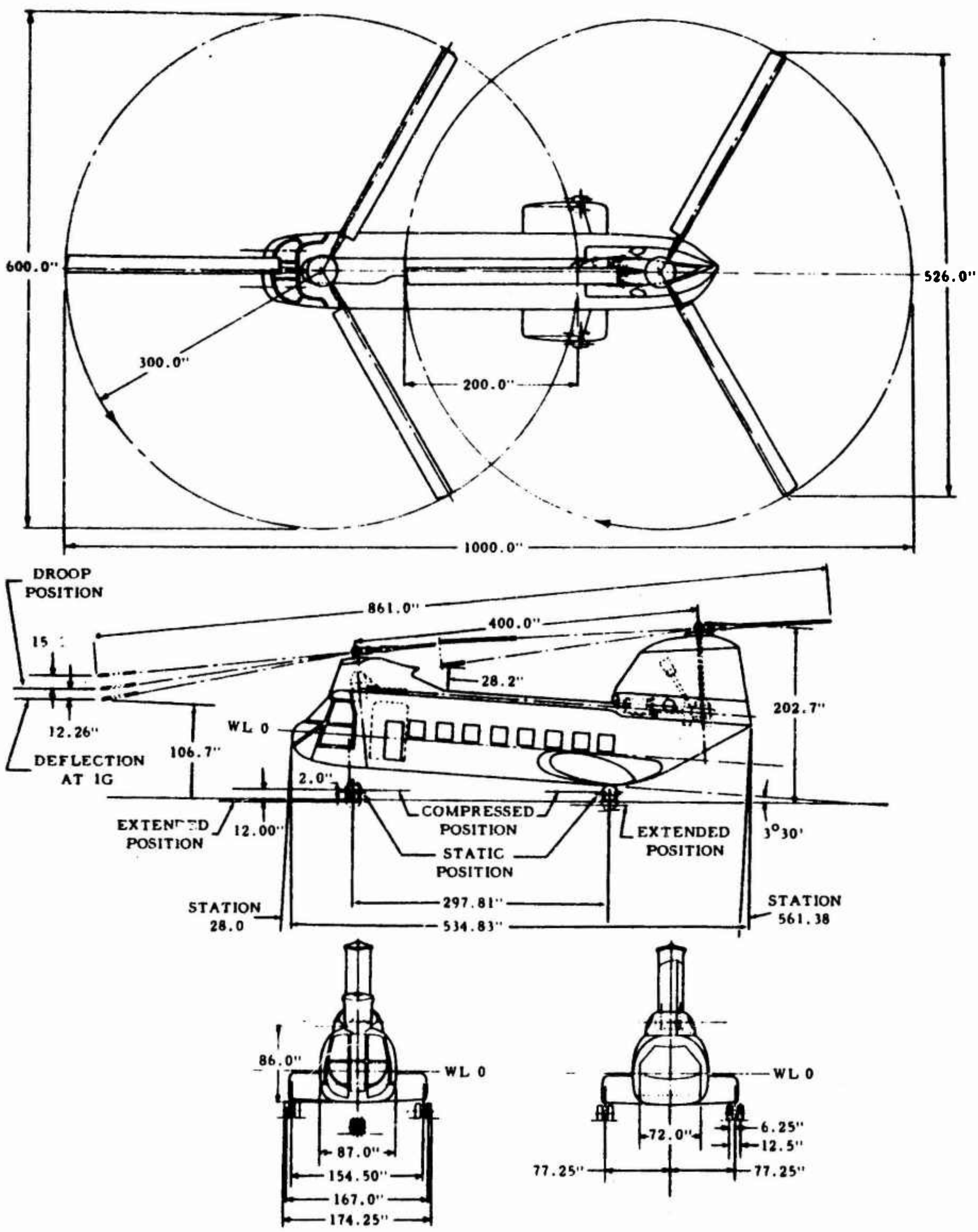


Figure A-13. Dimensions and Areas - Vertol 107-II Helicopter